Universitat Autònoma de Barcelona

A Tragedy of the Horizons?
Temporal perspectives on environmental policy

Mariateresa Silvi

Universitat Autònoma de Barcelona

A Tragedy of the Horizons?
Temporal perspectives on environmental policy

Mariateresa Silvi

PhD Dissertation

A Tragedy of the Horizons?
Temporal perspectives on environmental policy

Author:
Mariateresa Silvi

Supervisor:
Emilio Padilla Rosa

Universitat Autònoma de Barcelona

Department of Applied Economics
Universitat Autònoma de Barcelona

Barcelona, 2021

Al mio bimbo e al suo papà.

"Climate change action is difficult because our focus, evolutionarily, is on the here and now, and in the here and now reside the costs of action, not the benefits."

Elke Weber

Acknowledgments

I am grateful to Emilio Padilla Rosa, my PhD supervisor, for his continued guidance in the development of this thesis and for assisting me with learning the ropes of life in the academia. I also thank him for the continued patience he demonstrated towards my time-optimism and for sustaining my ambition in moments of shaking confidence. Without his knowledge and his calm skepticism, the dialogue that the ideas expressed in this thesis sparked from, would not have been possible. I also thank him for ensuring funding for my participation at international conferences and for the experiment in the final chapter.

I also wish to thank our PhD coordinator Prof. Rosella Nicolini for providing us with a solid background to face the publication and the job markets and for organizing courses that expanded our skillset. I thank Prof. Francesc Trillas for welcoming me to the PhD program and my other colleagues and other PhD students at the Department of Applied Economics for providing a stimulating audience where to test ideas and receive constructive feedback. I also thank Imma Ruano Moyano, Pilar Bernabé Conde, Angel Hermosilla Pérez and Montserrat Danés Tobias for their eagerness to help at every occurrence.

I am also grateful to Prof. Arild Vatn at the Norwegian University of Life Sciences for two highly formative weeks at the Thor Heyerdahl Summer School. The course he organized and co-taught has been an important brick in my background. I thank Professor Daniel Fiorino, at the Center for Environmental Policy at American University in Washington D.C. for welcoming me as visiting fellow, and for showing me, together with Dr. Joseph Greenblott at the Environmental Protection Agency, how the academia and public institutions can work together to address the environmental problems we are facing. I thank Dr. Jeremy Freese, Dr. Hannah R. Hamilton and Dr. James Druckman at the Time-Sharing Experiments for the Social Sciences for believing in and financially supporting the experiment presented in Chapter 2. I thank Prof. Brent Bleys, Prof. Nikolaos Georgantzis and Prof. Jeroen van den Bergh for agreeing to form my doctoral committee and two anonymous reviewers for validating my research.

I thank my husband, for being proud of me before I even achieved anything and for providing me full-round support throughout this journey, starting with encouraging the decision to suspend my UN career to join the academia; to the occasional help with Java coding and the more frequent confidence boosters. Finally, a thank you to my parents for enabling me to pursue higher education and, together with my brother, for being proud of me even when it wasn't yet clear what it was that I was after.

Table of Contents

INTRODUCTION

In 2017, a presenter at the 23rd conference of the European Association of Environmental and Resource Economists argued that every climate change presentation should start by showing the picture of a polar bear. Indeed, as recently as just four years ago, extreme whether events were rarer in occurrence and climate change was still, in the mind of many, an abstract construct; its most obvious representation being a white emaciated polar bear standing on a frozen slab of ice, floating above the sea.

Unfortunately, in the last few years, climate change has gotten a more tangible and relatable face: from the ethereal image of polar bears which very few people ever met in person, to the flames of wildfires, hitting in 2021 at an unprecedented scale, California, Australia and Siberia; the record breaking snow in Madrid or the epochal flooding in Western Germany and Belgium which caused deaths and destroyed homes.

But there is an upside. Human willingness to act depends on the "*perceived immediacy and the personal relevance of the threat*" (Slovic, 1982; Weber, 2006). These extreme whether events have likely been pivotal in transforming the public's perception of the urgency of climate change mitigation action, at the individual and at the governmental level. The perception of climate change, the acknowledgement that individual lifestyles must change and the public's acceptability of governmental intervention to safeguard the environment and the climate has greatly evolved since I started this PhD thesis a few years ago. The percentage of Europeans considering climate change a very serious problem raised from 68% in 2015 to 93% in 2021 (European Commission, 2015; 2021). Within the same timeframe, the percentage of United States adults that consider dealing with climate change a priority increased from 34% to 52% (Pew Research Center; 2020).

This thesis focuses on individuals intended as consumers that demand resources and that produce externalities in terms of waste and pollution. But also as the constituents of a polity, citizens of democratic governments, who can constrain their governors' range of action, by holding them accountable in the tight grip of short-term electoral cycles. In this thesis, I consider pro-environmental behavior (PEB) as any action that an individual undertakes or refrains from to minimize his/her negative impact on the environment and the climate (Kollmuss & Agyeman; 2002, p.240). This can include political behavior, such as voting, campaigning, or protesting in support for or against environmental policies of some sort.

Justification: why pro-environmental behavior

As I started this thesis, some academics in the field of environmental and ecological economics would diminish the importance of PEB as a research and policy topic in its own right. In their views, PEB served industries' blame-shifting strategy towards consumers, and it justified industries' inaction and the status-quo. To them, it was industries that needed to change, and governments that had to act, not the people.

There are however at least three reasons for which individuals, as consumers and as political actors, need to be involved, and the determinants of their behavior and the dynamic of political consensus need to be understood. The first reason is that individual action is inextricably linked in an interdependent systemic relationship with industries and the government. The second reason is that the large majority of world greenhouse gas emissions can be directly linked to household behavior. The third reason relates to the moral imperative for individuals to limit their impact on the environment and the climate. I briefly address these reasons below.

Systemic interdependence. As Tim Jackson agues in "Prosperity without growth" (2009), individuals, industries and governments are all essential actors, all of whom need to be part of the change, to break the "iron cage of consumerism". Industries will not develop less polluting and or more circular products

unless there would be a demand for them. And governments, tied by the short term necessity of staying in power would not pass policies that impose immediate costs on their constituencies to achieve distant environmental objectives, unless supported by a majority of their citizens. Therefore, individuals are not just influenced by the government and industries but can also influence them in return.

Emissions accounting. Beyond that, there are limits to what the government and industries can do. Research has shown that government policies and technological change and innovation alone, will not be able to abate emission to the extent that is needed to avert the worst consequences of climate change, and that two thirds of the effort should come from behavior change (van den Bergh, 2013; IEA, 2021). Social norms and individual behavior will be essential in determining the shift towards a net-zero energy system by 2050 (IEA, 2021).

Moral responsibility. Since the damage to the environment and the climate arises only from the cumulative effect of many individual acts, but the single individual act in itself does not make a difference; the ethical responsibility of the individual may not seem straightforward. Yet, from a philosophical perspective, there's nowadays a near consensus in that acting to curtail one's own emission is a moral imperative. Most notably, from a co-operative utilitarian standpoint, we each *"ought to co-operate, (...) in the production of the best possible consequences"* (Regan, 1980, Ch. 8). But also from a consequentialists perspective, one must recognize that even a single individual action might indeed have consequences, either by making an imperceptible difference or by triggering tipping points, and it therefore falls within the realm of moral relevance (Kagan, 2011).

Focus: temporal perspectives

This thesis is articulated in three independent chapters. The red thread which connects these three papers is the focus on the relationship between environmental policy, individual decisions and time. The notions of time explored in this thesis span from considering i) time as a socio-cultural attitude —with certain nations being more future-focused than others—; ii) time as an individual preference that classify individuals as either impatient or forward-looking; and iii) time as the embedded, yet hidden contextual feature of environmental decision-making and policies. The next paragraphs introduce the three notions and summarize how the chapters explore them.

Time as a socio-cultural attitude

Geert Hofstede identified six socio-cultural dimensions that explain differences among nations and that can be used to explain behaviors (Hofstede, 2015). One of these dimensions is the long/short-term orientation scale, a 0–100 index which identifies to what extent the nationals of a country focus on preparing for the challenges of the future.

The first chapter of my thesis proposes a holistic approach to understand the determinants of eight PEBs, from saving water to reducing car use. It focuses on the European Union's 27 member states and the United Kingdom. It investigates whether difference in the EU's PEB depend on differences in the intrinsic motivation of their national populations, in the socio-cultural values that are predominant at the national level or in the availability of green infrastructures. Through the econometric analysis of 28,000 survey responses, the chapter concludes that providing external incentives or green infrastructures is not effective if not supported by a minimum level of intrinsic motivation to behave pro-environmentally. Consequently, differing outcomes at EU level depends on differing perceptions about the importance of observing an environmental norm, from whether individual acknowledge responsibility for the environment and whether they are worried about a specific environmental issue. Lack of these three factors or a combination thereof is the lead cause for individuals lack of environmental action. We also find that individuals living in more long-term oriented societies are more likely to adopt a higher number of PEBs. This finding is expected since caring for the environment implies the ability to take into consideration future consequences. We conclude by recommending policy makers to consider extrinsic incentives, green infrastructures and the promotion of intrinsic motivation as complementary rather than alternative policy levers; and to be wary of the interaction between them. We advise that the availability

of enabling mechanisms (such as the infrastructural or the economic accessibility of a behavior) and the level of environmental motivation and concern among the population should be assessed first, in order for policy makers to identify which policy lever or combination thereof should be promoted. This chapter has been published online by the journal of Environmental Policy and Governance on 27 July 2021 and is awaiting to be included in an issue (Silvi & Padilla, 2021).

Time as an individual preference

Immediate survival used to be the primary focus of the human brain. Humans' limited cognitive abilities required human attention to be focused on individuals and problems that are socially and temporally proximal (Weber; 2017). Elke Weber wrote that our brain has not evolved to meet the evolutionary challenge of climate change and that biases such as present-orientedness limit our abilitiy to engage in environmental preservation (Weber; 2017) that typically requires undertaking sacrifices today for long-term objectives. In the view of behavioral economists, the cognitive limitations of the human brain can however be used as a resource, since they imply that individual preferences are susceptible to manipulations. Time, in particular, is a contextual feature that can be pushed in the background or brought to preeminence with framing techniques (Ebert and Prelec, 2007).

The second chapter of my thesis, focuses on one specific PEB: the decision to buy an energy-efficient appliance. Energy-efficient investments offer the ideal scenario to study the intertemporal dimension of environmental decision making, since it often implies accepting an immediate additional cost for financial and environmental benefits that materialize in the long-term. We present a nationally-representative sample of 2,010 United States adults with an hypothetical choice experiment consisting in a replacement decision concerning a refrigerator. We design 6 conditions, identified by a 3x2 factorial design. One factor corresponds to 3 different ways of framing electricity information and the second factor pertains to the number of appliance attributes that are shown to participants. We leverage two known behavioral biases, the *hidden-zero effect* (Loewenstein & Prelec; 1993) and the *delay/speed-up asymmetry* (Weber et al., 2007) and we find that highlighting the long-term opportunity costs of choosing a cheaper but inefficient appliance increases energy-efficient choices by 24 percentage points compared to the control group and by 7% point compared to previous experiments in the literature, that merely showed lifetime operating costs. We show that individual temporal preferences, exogenously measured, affect appliance choice, with more impatient individuals being less likely to purchase the efficient appliance *ceteris paribus*. Yet, we show that the marginal effect of our treatment is the highest on more impatient individuals. We think this offers evidence that when information is framed to display preeminently the future implications of a person's present choices, the effect of pre-existing impatient preferences is diminished. This is to the best of our knowledge the first paper to leverage temporal framing techniques in support of environmental decision-making. To carry out this experiment we were awarded funding from the Time- Sharing Experiment for the Social Sciences, a program by the United Stated National Science Foundation. This chapter has been published online by the journal of Energy Economics on 10 September 2021 (Silvi & Padilla, 2021.b).

Time contextual feature of environmental policy

Sixty years ago, Garret Hardin connoted the term the Tragedy of the Commons to indicate that protecting the commons was unattainable because exploiting a common resource beyond its sustainability leads to private payoffs whereas the benefits of preserving resources are shared (Hardin, 1968). While Ostrom (1990) demonstrated that with monitoring and sanctioning systems in place the commons can be protected, the term has stayed to characterize open access common pool resources, such as the atmosphere or fisheries that are open-access (Libecap, 2008). But there is also a Tragedy of the Horizons hampering the protection of the commons. The fruits from the sacrifices individuals and organizations could undertake today to protect resources will mostly be enjoyed in the very long term. This intertemporal dimension is particularly pronounced for the climate commons, where the efforts undertaken today will mostly be felt by other generations, which undermines political support in favor of climate regulation (Gollier, 2020). The temporal distribution of the environmental future benefits rewards and of the costs it imposes naturally influences choices and the likelihood of achieving

successful cooperation through individual climate mitigation efforts in real-world social dilemmas. To achieve successful cooperation in intertemporal environments, it is crucial to understand: i) the influence that the temporal context of the decision has on decision outcomes; ii) the role individual time preferences and altruism play in the decision to cooperate; and iii) the interplay between individual temporal preferences and the temporal context. There is evidence from intertemporal choice that individuals are more likely to engage in activities that prize the future when they can pre-commit to do it later in time. Pre-commitment mechanisms are at the basis of the success of saving schemes such as "Save More Tomorrow" and also key to the success of cooperation in collective dilemmas alike.

In the third chapter we focus on the public acceptability of carbon taxes, we explore whether US citizens would be more favorable to the introduction of a federal carbon tax, if its start date is delayed by either 3 or 6 years and if its environmental objectives are expressed by 2030 or by 2050. We conduct a survey experiment on a nationally-representative sample of 1,000 US adults and we find that the approval of a carbon tax increases when its start date is postponed by a few years. However, when individuals are informed of the opportunity costs of delaying the tax —the additional cost per ton of CO_2 which is needed to avoid the global climate to warm beyond 1.5–2 ºC degrees above pre-industrial levels— they start trading off postponing the introduction of the cost with the tax increase. Tax acceptance also increases when a more long-term commitment, leading to more ambitious environmental objectives is presented. We show that individual temporal preferences affect choices, with more impatient individuals being less likely to approve the tax, but in general being more in favor of a delayed introduction. We conclude that postponing the introduction of carbon taxes to avoid facing the public's opposition may be counterproductive in the longer term, as political opposition is expected to grow proportionally with the delay and the increased mitigation costs they would imply.

The effect of time on environmental policy and decision-making is a vastly unexplored research topic. I hope that this thesis has contributed to demonstrate that temporal preferences and the embedded temporal context of environmental choice contexts are relevant in determining individual behavior and the public approval of environmental policies. Individuals have a tendency to forego immediate costs, especially if those costs are justified by an intangible and temporally distant goal. But by gaining awareness of how time affect individual choices, we can craft decision environments that neutralize the effect of impatience without constraining the choices that are available to the individual.

References

Ebert, J. E. J., & Prelec, D. (2007). The Fragility of Time: Time-Insensitivity and Valuation of the Near and Far Future. Management Science, 53(9), 1423–1438. https://doi.org/10.1287/mnsc.1060.0671

European Commission. (2015). Special Eurobarometer 435 "Climate Change". Brussels.

European Commission. (2021). Special Eurobarometer 435 "Climate Change". Brussels.

Gollier, C. (2020). Climate economics form theory to policy. EAERE Magazine. n.8 Winter 2020, p. 6-8

Hardin, G. (1968). The tragedy of the commons. Science (New York, N.Y.), 162(3859), 1243–1248. https://doi.org/10.1126/science.162.3859.1243

Hofstede, G. J. (2015). Six dimension of culture by country. Retrieved February 27, 2018, from http://geerthofstede.com/research-and-vsm/dimension-data-matrix/

International Energy Agency. (2021). Net Zero by 2050. A roadmap for the global energy sector. Paris.

Kagan, Shelly (2011). Do I Make a Difference? Philosophy and Public Affairs 39 (2):105-141.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environmental Education Research, 8(3), 239–260.

Jackson, T. (2009). Prosperity without growth: Economics for a finite planet. London: Earthscan.

Libecap G.D. (2008) State Regulation of Open-Access, Common-Pool Resources. In: Ménard C., Shirley M.M. (eds) Handbook of New Institutional Economics. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-69305-5_22

Loewenstein, G. F., & Prelec, D. (1993). Preferences for sequences of outcomes. Psychological Review, 100(1), 91–108.

Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge: Cambridge University Press.

Pew Research Center. (2020). How Americans see climate change and the environment in 7 charts. Retrieved August 1, 2021, from https://www.pewresearch.org/fact-tank/2020/04/21/how-americans-see-climate-change-and-the-environment-in-7-charts/ft_2020-04-21_earthday_02a/

Regan, Donald H. (1980). Utilitarianism and Co-Operation. Oxford University Press.

Silvi, M. & Padilla, E. (2021.a). Pro-environmental behavior: Social norms, intrinsic motivation and external conditions. Environmental Policy and Governance, 1–14 https://doi.org/10.1002/eet.1960.

Silvi, M. & Padilla, E. (2021.b). Reversing impatience: Framing mechanisms to increase the purchase of energy-saving appliances. Energy Economics, 103, 105563. https://doi.org/10.1016/j.eneco.2021.105563.

Slovic, Paul. (1982). Perception of Risk. Science 236: 280–285.

van den Bergh, J. C. J. M. (2013). Environmental and climate innovation: Limitations, policies and prices. Technological Forecasting and Social Change, 80(1), 11–23.

Weber, E. U. (2006). Experience-based and Description-based Perceptions of Long-term Risk: Why Global Warming Does Not Scare Us (Yet). Climatic Change 77: 103–120.

Weber, E. U., Johnson, E. J., Milch, K. F., Chang, H., Brodscholl, J. C., & Goldstein, D. G. (2007). Asymmetric Discounting in Intertemporal Choice. *Psychological Science*, *18*(6), 516–523. https://doi.org/10.1111/j.1467-9280.2007.01932.x

Weber, E. U. (2017). Breaking cognitive barriers to a sustainable future. Nature Human Behaviour, 1(1). https://doi.org/10.1038/s41562-016-0013

1

Pro-environmental behavior: Social norms, intrinsic motivation and external conditions

Abstract

Pro-environmental behaviors (PEBs) have been linked in the literature to social norms, intrinsic motivation and external conditions. However, no study has jointly analyzed these factors on a cross-country dataset and given a holistic explanation of the variance observed in the adoption rates of PEBs across countries. Using a dataset measuring individual adoption of eight PEBs in the European Union's 28 member states (in 2018), we econometrically test these three groups of factors on a wider scale. We assess the importance of intrinsic motivation as a dominant factor and show how differing levels of intrinsic motivation influence the effectiveness of external conditions, such as monetary incentives and green infrastructures. The results suggest that two-pronged policies, which take into account intrinsic motivation and external conditions, are needed to reach a high observance rate in the population in the short and in the long term. The wider significance of these results for policy is discussed.

Keywords

economic incentives, environmental attitudes, green infrastructure, intrinsic motivation, pro- environmental behavior

1.1 Introduction

Understanding the determinants of pro-environmental behavior (PEB) in different contexts is important to designing policies that can promote more sustainable lifestyles across the European Union's (EU) socio-economic and culturally varied nations. Data show that environmentally friendly behaviors differ widely among the population of the EU member states. As an example, in 2014 the actual rate of municipal recycled and composted waste ranged between Germany's 64% and Slovakia's 10% (European Environment Agency, 2017); while 60% of Swedes reported buying green label products as opposed to 9% of Portuguese citizens (European Commission, 2015). This article explores such heterogeneity by empirically investigating the contribution of different determinants of PEB in the EU. To this purpose we run a microeconometric analysis using a database counting 28,000 individual observations evenly distributed across EU's 28 members[1], and covering 8 PEBs.

The literature on the determinants of PEBs is vast, yet the near entirety of contributions focuses on local contexts, which limits the potential applicability of findings to other areas. Additionally, while the literature has already reached robust conclusions regarding the contribution of either intrinsic motivation or external conditions taken singularly, studies which account for both are rare. They reached contrasting findings and mostly focused on interaction effects—that is, whether providing extrinsic incentives can crowd out intrinsic motivation to act pro-environmentally—, while disregarding that heterogeneity across individuals can lead them to react differently to the same policy. Consequently, the existing literature cannot entirely explain the variety of results in the EU, as socio-cultural differences, intrinsic motivation and external conditions—such as the green infrastructures available—have a role in jointly determining different outcomes in the EU.

This article addresses this gap in the literature by:

1. Using a cross-country dataset to offer generalizable conclusions applicable to different European geographical areas.
2. 2. Simultaneously including multiple factors affecting PEB—such as social and individual values, and the green infrastructures locally available—to identify the most impactful ones.
3. 3. Defining whether the effectiveness of external conditions and green infrastructures are subject to individual heterogeneity— assessing whether individuals with differing intrinsic motivation respond differently to the same green infrastructure.

The remainder of this article is organized as follows: Section 2 synthesizes the most relevant existing empirical studies; Section 3 introduces our analytical outline; Section 4 describes our data sources and includes a qualitative data analysis. Section 5 reports and discusses results and Section 6 concludes with key messages and policy implications.

1.2 Literature review

Like most human behaviors, PEB is jointly determined by cognitive processes that are internal to the individual and by the external context that surrounds her/him. However, PEB has traditionally been studied either as: (i) the outcome of an internal process of moral deliberation in which the individual supposedly acts in complete autonomy from her/his external context (Bamberg & Möser, 2007; Black et al., 1985; Grodzińska-Jurczak, 2003; Heberlein, 1981; Hopper & Nielsen, 1991; Liobikienė et al., 2016; Sidique et al., 2010); or (ii) the consequence of an external stimulus to which the individual responds as an automaton regardless of her/his own convictions (Ferrara & Missios, 2005; Jacobs & Bailey, 1983; Linderhof et al., 2001; Palmer & Walls, 1997).2[2] Consequently, policy recommendations

[1] We include in the count United Kingdom, which was still a EU member state at the time our dataset was created and at the time this paper was being written.

[2] A dicothomy first defined by Guagnano et al.(1995).

have typically focused on one of these two aspects, favoring either educational interventions or alterations of external conditions through incentives or taxes (Fehr & Gintis, 2007; Guagnano et al., 1995; Turaga et al., 2010). While both approaches have demonstrated some validity, later evidence that human behavior is determined by both internal and external factors and their interaction has supported the development of integrated frameworks (Jackson, 2005; Kirakozian, 2016; Turaga et al., 2010; van den Bergh, 2008).

Previous research accounting for both intrinsic motivation and the external context have focused on case studies and field experiments (De Young, 1985; Derksen & Gartrell, 1993; Guagnano et al., 1995; Heller & Vatn, 2017; Humphrey et al., 1977; Katzev & Pardini, 1987)—restricting the potential applicability of the findings to the particular socio-cultural context involved. Extending the analysis to several countries offers two advantages: it highlights national differences, and the reasons behind them. To the best of our knowledge there are only two cross-cultural studies in the literature that have included both sets of variables. Cecere et al. (2014) concluded that waste reduction behavior is more strongly driven by intrinsic motives as opposed to extrinsic incentives across the EU-27. However, their paper identified external incentives with the social visibility and desirability of a given behavior, a narrow definition that excludes the material factors that facilitate or hinder a behavior. We instead consider external conditions as the availability of green infrastructures or monetary incentives to facilitate PEB. Ferrara and Missios (2012) assess the relevance of intrinsic motivation and different waste collection policies for ten countries located across the five continents. They find that intrinsic motivation and the availability of recycling facilities are highly relevant in determining behavior, while the presence of monetary incentives to recycle—such as weight and volume based pricing schemes—are not very effective. The authors acknowledge that the validity of the latter result may however be undermined by the scarcity of data available for each pricing scheme. Furthermore, while recognizing differences among countries, the study cannot identify whether such differences are due to divergent socio-cultural values or institutional differences (i.e., regulations and policies). By including indexes of predominant socio-cultural values in our econometric model we can capture whether national differences are due to cultural factors. Following Liobikienė et al. (2016), who proved the relevance of social values in explaining green purchases in different countries, we use five of the six socio-cultural dimensions identified by socio-psychologist Geert Hofstede (Hofstede & Minkov, 2010).

Some of the studies accounting for both intrinsic motivation and external conditions focused on a particular aspect of the relationship between these two groups of variables —analyzing whether providing external incentives crowd out the moral motivation to sort waste (Ferrara & Missios, 2012; Heller & Vatn, 2017; Thøgersen, 1994; Thøgersen, 1996; Thøgersen, 2003). While they analyze an important aspect, the relationship between intrinsic and external conditions extends to other related and unexplored research questions, such as whether the two groups of variables are effective conditionally to each other (Guagnano et al., 1995). For example, external incentives may be ineffective if not supported by a basic level of intrinsic motivation, but strong intrinsic motivation may also be ineffective on its own with a complete lack of green infrastructures.

This article contributes to the understanding of the conditions under which internal motivation is conducive of PEB and when providing external incentives—such as the provision of monetary incentives and green infrastructures—can be effective. The literature has observed that individual heterogeneity can result in different responses to external conditions (Beretti et al., 2019; Gneezy et al., 2011). By clustering individual responses based on their level of intrinsic motivation we can record whether the effectiveness of green infrastructures and economic incentives to recycle vary across groups. This approach has the advantage of enriching the debate by highlighting why individuals respond differently to the same external conditions.

1.3 Theoretical framework

The Norm Activation Model (NAM) is a theory designed to understand how pro-social behavior is affected by internalized norms (Schwartz, 1977). It is one of the most prominent social psychology theories that have been applied to the understanding of PEB (Onwezen et al., 2013). It models altruistic behavior as the result of a cognitive process within the individual. Developed by socio-psychologist Shalom H. Schwartz between 1968 and 1977, the theory analyzes the gap between an intention to act and actual behavior. It identifies those key emotions that, if anticipated, help an intention to translate into actual behavior. While this approach helps explaining individual heterogeneity in altruistic behavior, it cannot account for the effect of external conditions; nor for their interaction with intrinsic motivation. The Attitude–Behavior Context (ABC) model completes the NAM, by incorporating it into a broader framework that also includes external conditions such as physical structures, social institutions and economic incentives (Guagnano et al., 1995). Our theoretical framework applies the ABC model, by maintaining the intrinsic factors specified in the NAM. In the next paragraphs we summarize the two theories and describe how they complement each other.

1.3.1 The Norm Activation Model

The NAM aims to explain the cognitive process and the circumstances under which a personal moral norm is activated into behavior. The NAM has proven more fit to explaining PEBs compared to alternative socio-psychological theories of behavior, both conceptually (Thøgersen, 1996) and empirically (Cordano et al., 2011). Numerous papers have corroborated NAM's main hypothesis in its application to PEB (Black, 1978; Cordano et al., 2011; Stern et al., 1985). The PEBs studied in the context of NAM include: recycling, energy conservation, automobile use or travel-mode choice, support for environmental laws and regulations, and willingness to pay for environmental protection or for greener products (see Guagnano et al., 1995, for a review of the literature).

The theory posits that an individual will behave in accordance with a norm if she/he acknowledges the norm (i.e., she/he has internalized a social norm) and if the following two conditions apply simultaneously: (1) the person must have some awareness that her/his potential acts may have consequences for the welfare of others—awareness of consequences; (2) the person must ascribe some responsibility for these acts and their consequences to herself/himself—ascription of responsibility (Schwartz, 1968). We capture these three indicators within our econometric model. The NAM mentions that the external context may have a role in materially facilitating certain behaviors but it does not specify the conditions under which it happens nor the existing relationships between them. The ABC theory was developed 15 years later to enhance the NAM theory by addressing these points.

1.3.2 The Attitude-Behavior-Context model

The ABC model postulates that the prevalence of a certain behavior in a given population will depend from both their attitudes towards that behavior (internal factors) and external conditions, intended as “any external source of support or contrast to behavior, whether physical, financial, legal or social” (Guagnano et al., 1995, p. 702). Intrinsic motivation (referred to by the authors as attitudes) can vary on a scale from extremely negative—the person would perform the behavior only if forced to—, or very positive—the person would autonomously apply the behavior. Likewise, external conditions can be very negative— making it difficult to perform the behavior—, or they can facilitate the behavior—making it easy or pleasant. In our article, we define external conditions as the combination of the physical facilities available to facilitate PEB (e.g., biking lanes; recycling bins; public transport lines; etc.), and the economic incentives put in place to promote PEB.

According to this theory, the effectiveness of a policy aimed to either influence attitudes or external conditions will depend on both intrinsic motivation and external conditions, rather than on the magnitude of a single policy intervention. According to these authors, if the external conditions are extremely unfavorable or favorable to PEB, intrinsic motivation will not affect behavior, since regardless of how

intrinsically motivated they are; people would be unable to follow the behavior in the first case or would do it anyway in the latter. For example, an educational program to improve environmental awareness will not have an impact on the population's littering behavior in a context in which there are no trash bins or, on the contrary, if there are already bins everywhere and heavy fines for not using them. Similarly, Derksen and Gartrell (1993) found that intrinsic motivation can enhance recycling rates but cannot overcome the barriers represented by a lack of infrastructures alone.

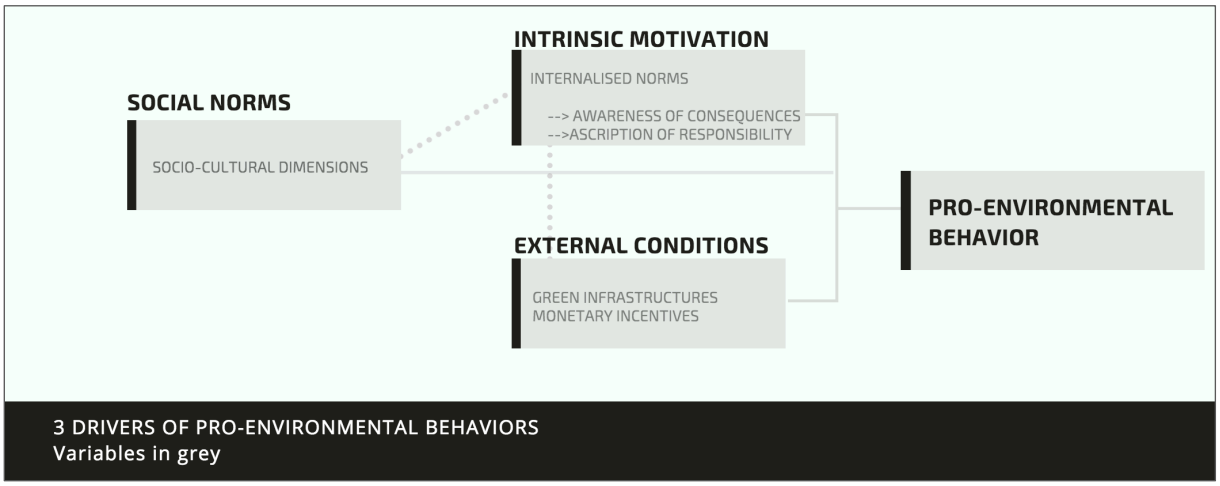
In this model, the opposite also applies: a policy focused on changing the external conditions of a behavior will not be particularly effective on individuals that have a very negative attitude towards the behavior, nor it will affect individuals that were already very motivated and would have applied the behavior nonetheless. Empirical studies have supported the idea that the response to policy interventions differs based on user motivation (Abrahamse et al., 2005) and that communication campaigns can be ineffective if targeting those who are already intrinsically motivated (Arkesteijn & Oerlemans, 2005). Previous studies have highlighted that easier, less costly behaviors are more likely to be adopted (Attari et al., 2011) and that in these cases intrinsic motivation can be a strong predictor of PEB (Black et al., 1985). Conversely, higher costs of compliance act as a limiting factor that impedes intrinsic motivation from translating into actual behavior (Black et al., 1985).

Thus, the ABC model enables to identify boundary conditions that must be met, for a policy to be effective on behavior. It guides the policy maker to adopt a more holistic approach, by helping her/him to anticipate the potential limitations of a single policy intervention. Are citizens of a country, sufficiently motivated to recycle, such that they would respond to a small monetary incentive to do it? Is the public transport network sufficiently developed such that an educational campaign on its environmental benefits could be enough to shift behavior?

1.3.3 Causal model of relationships

Both models refer to social norms as forces that influence behavior. The NAM proposes that internalized norms are derived by the social norms predominant in the society the individual lives in. The ABC model instead, considers social norms as a source of external influence, affecting behavior directly. To account for this component, in our model we include country level social norms, taken from Geert Hofstede's six cultural dimensions theory indicators. The six dimensions were identified between 1963 and 2010 and they register the main socio-cultural differences among countries (Hofstede & Minkov, 2010). Figure 1.1 summarizes our theoretical framework. We propose that PEB is determined by three classes of factors: (i) social norms, (ii) internalized individual norms and internal factors leading to their activation (awareness of consequences and ascription of responsibility); and (iii) external conditions facilitating the behavior. The three factors are interrelated among each other. Social norms affect behavior in two ways: indirectly, through internalized norms that are socially derived, but also directly, through peer-pressure to comply with observable social norms. Finally, the level of intrinsic motivation affects the effectiveness of external conditions. The figure reflects the focus of our article although it is clearly not exhaustive, as other factors or relations may also influence PEB.

FIGURE 1.1 Causal model of relationships



Source: Own figure partly based on Schwartz (1968), Hopper and Nielsen (1991), and Guagnano et al. (1995)

1.4 Materials and methods

1.4.1 Data sources

We access data from the Eurobarometer's 2014 survey on "attitudes of Europeans towards environment" (European Commission, 2015), which surveyed 28,000 respondents in the EU's 28 member states. The respondents who did not reply and replied "do not know" to at least one of the questions relevant to this analysis were excluded from the data set; this reduced the sample size to nearly 23,000–25,000 observations, depending on the analysis carried out.

The Eurobarometer data set provided our response variables. It registers whether respondents reported having performed eight PEBs in the previous month: waste separation for recycling; reduction of waste—by avoiding over-packaged products and buying products with a longer life; reduction of domestic water consumption; reduction of domestic energy consumption; purchase of green-label products; purchase of local products; choice of a greener way to travel; and diminished car use. The same dataset also provided the following types of causal variables: indicators of intrinsic motivation; proxies measuring the availability of green infrastructures; self-reported economic problems; demographic controls—age, gender, and years of education.

We integrated the database with two additional sources. First, a variable measuring the availability of green infrastructures that considers whether a country has adopted a container deposit collection system, that is, BottleBill, which rewards individuals economically for returning used bottles and vessels. The list of countries that had adopted this legislation by 2014, the year of the Eurobarometer survey, was taken from the website BottleBill.org, maintained by the non-profit organization Container Recycling Institute (Container Recycling Institute, 2016). The list was incremented using evidence from a European Parliament report on refunding schemes for drink containers (Schneider et al., 2011). It represents in our model a monetary incentive to recycle at the national level. Second, the Hofstede cultural dimension country level indicators were taken from Geert Hofstede own website GeertHofstede.com (Hofstede, 2015).

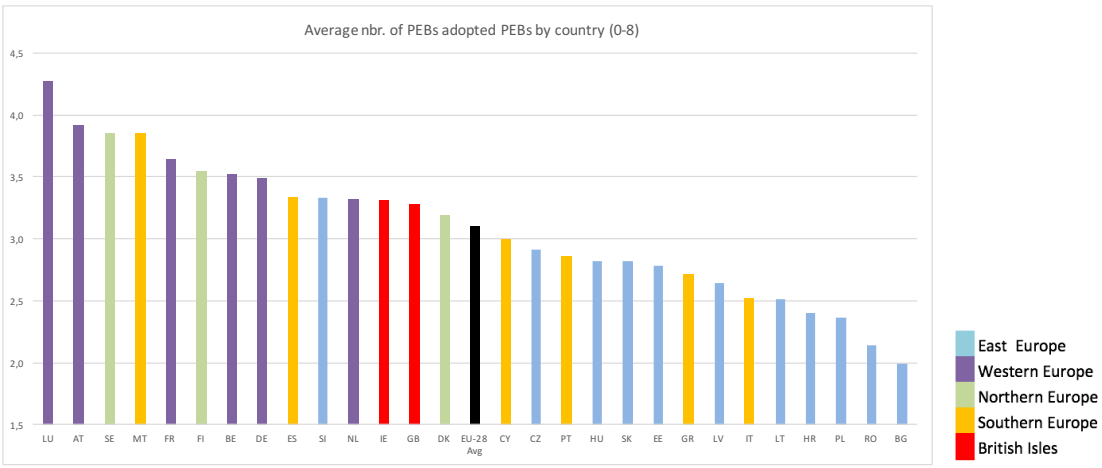
1.4.2 Qualitative analysis

In this subsection we first qualitatively analyze the variance of PEBs within EU countries. We then observe the distribution across countries of two classes of determinants, intrinsic motivation and external conditions, with the aim of identifying regional patterns that may explain such variation. We classified

and color-coded countries based on their geographical area to highlight possible similarities between countries that share similar geographic and cultural features: Eastern, Western, Northern, Southern Europe and the British Islands.

The average number of PEBs adopted by individuals (on a 0–8 scale) per country varies between 2 in Bulgaria and 4.3 in Luxemburg (Figure 1.2). With a few exceptions, we identify patterns, with same color countries being close to each other in the figure. On average, Western and Northern Europe countries tend to have a higher number of PEBs adopted compared to Southern and Eastern Europe countries which are concentrated towards the right hand side of the figure.

FIGURE 1.2 Self-reported average number of PEBs in EU-28 by country (2014)



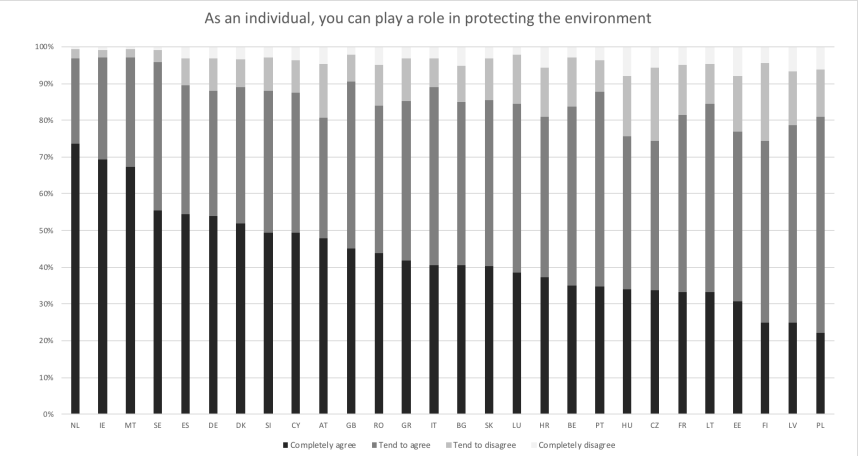
Source: Own computations based on data from the European Commission (2015)

However, the ranking of countries changes depending on the behavior observed; for example, Southern Europe countries are the most dedicated to saving water whereas Northern Europeans are more likely to shop green label products. These differences could be due to diverging national priorities and environmental worries (i.e., water scarcity is more likely to plague Southern Europe); but also different economic possibilities (green label products are usually pricier and may be more accessible to on average wealthier Northern European nationals).

The level of ascription to personal individual responsibility for the environment also varies widely among countries (Figure 1.3). The percentage of individuals ascribing to the highest level of personal responsibility to preserve the environment on a 0–4 scale varied between 74% in the Netherlands and 22% in Poland. While the proportion of individuals who reject any responsibility ranged between 1% in Sweden and 8% in Hungary.

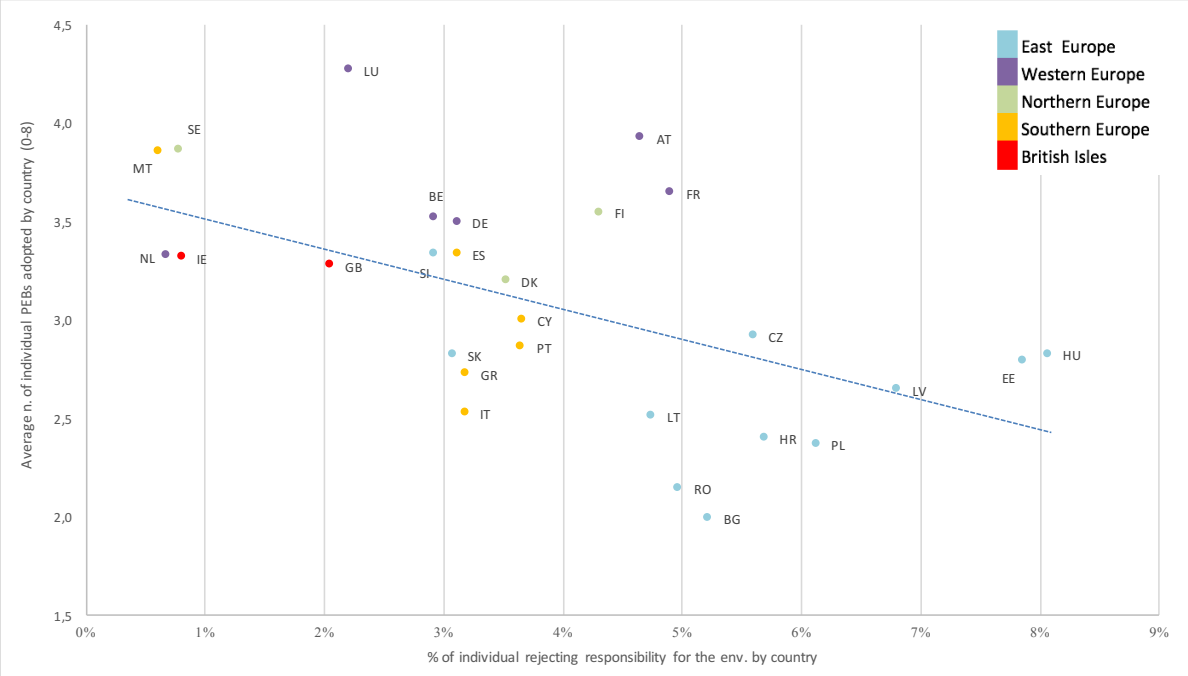
By plotting these last percentages against the average number of PEBs adopted by the population we find a negative relationship between these two (Figure 1.4). This negative correlation may be a sign that national level differences in the adoption rates of PEBs is channeled by differing level of individual responsibility. This negative correlation could signify that countries with lower adoption rates of PEBs may fail to instill a high sense of individual responsibility for caring about the environment. We further notice regional patterns with Eastern Europe countries clearly gathered in the bottom right of the figure; Southern countries mainly clustered in the middle; while Western and Northern Europe countries are distributed within the upper left corner. Regional proximity likely reflects socio-cultural proximity, in the next section we use indexes of predominant socio-cultural values to test whether they influence PEB adoption rates.

FIGURE 1.3 Ascription to personal individual responsibility for the environment in the EU-28 by country (2014)



Source: Own computations based on data from the European Commission (2015)

FIGURE 1.4 Self-reported average number of PEBs in EU-28 by country (2014)

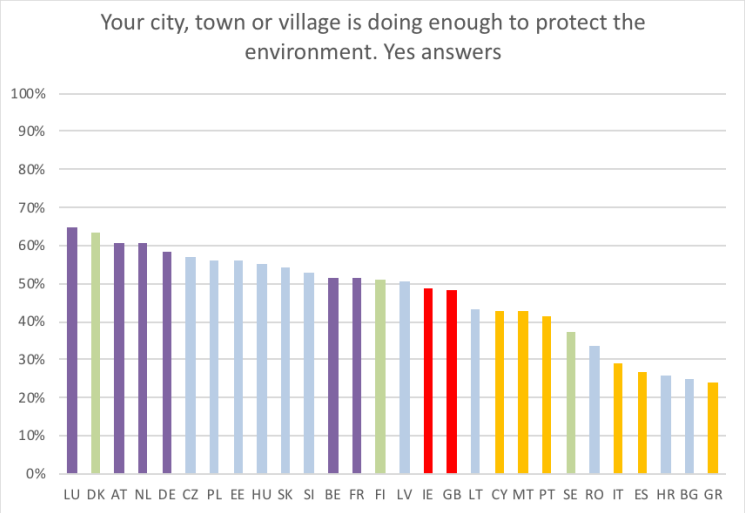


Source: Own computations based on data from the European Commission (2015)

With regard to external conditions variables, individual assessments regarding the availability of green infrastructures vary with only 24% of Greek respondents considering that their local government is doing enough for the environment as opposed to 65% of Luxembourgers (Figure 1.5). Also in this figure, a clear regional pattern emerges with Western Europeans showing more satisfaction with the green infrastructures available to them and Southern Europeans showing a higher discontent.

Moreover, at the time of the Eurobarometer survey (2014), only 11 of the then 28 EU's countries had adopted a Container Deposit system that rewards economically individuals who returned used vessels for reuse or recycling, they are nearly evenly distributed across regions.

FIGURE 1.5 Individual assessment of local green infrastructures in EU-28 by country (2014)



Source: Own computations based on data from the European Commission (2015)

1.4.3 Econometric approach

In this section we run separate regressions using a logit regression for each of the eight PEBs, to assess how the odds that an individual *(i)* will adopt a certain PEB *(b)* are affected by the joint influence of predominant socio-cultural values in her/his country *(c)*, by her/his personal level of intrinsic motivation to undertake that specific behavior, by her/his own assessment of the green infrastructures locally available and by the presence of a container deposit scheme in her/his country. We also run an OLS regression to assess how the total number of PEBs adopted by each individual is affected by the same set of variables.

$$PEB_{(i,b)} = F(socio-cultural\ values_{(c)}, intrinsic\ motivation_{(i,b)}, external\ conditions_{(i,c)}) \qquad (1)$$

The response variables $PEB_{(i,b)}$ capture whether an individual *(i)* reported having engaged in one of the eight behaviors *(b)* in the previous month.

- For $b = 1$ it is a 0–8 scale measuring how many of the 8 considered PEBs the individual reported having performed in the last month.

- For $b = 2$–9 it is a 0–1 dummy variable measuring whether the individual has performed PEB b in the last month. It is set to 0 if the respondent has not and 1 otherwise.

The full list of explanatory variables and their description is included in Table 1.1. We first run the model against the entire dataset, with the sole exclusion of Cyprus, for which we lacked data on socio-cultural values. We then re-run the model using logit regression after clustering groups depending on their level of ascription of responsibility for caring for the environment. Three levels of responsibility are identified, $HighResp_{(i)}$, $MediumResp_{(i)}$ and $NoResp_{(i)}$. Comparing the results across the three groups for a given PEB should give an indication of whether different individuals—as identified by varying degree of ascription of responsibility—react differently to the same external conditions. This analysis contributes to the understanding of whether intrinsic motivation is a precondition for PEB and whether its absence has an impact on the effectiveness of monetary incentives and green infrastructures.

TABLE 1.1 Explanatory variables definition and description[a]

Variable	Description
	Intrinsic Motivation variables
$NORM_{(i,b)}$	0–1 dummy variable measuring the recognition of the environmental norm connected to the PEB examined; for example, the response to the question "Do you think it is a priority for people to separate waste for recycling?" is used for recycling behavior.a For b = 2–9 it is set to 0 if the respondent did not recognize the behavior specific norm and 1 otherwise. For b = 1 it is set to 0 if the respondent did not recognize any environmental norm and 1 otherwise.[b]
$ENVWORRY_{(i,b)}$	0–1 dummy variable measuring individual concern with the environmental aspect connected to the PEB examined; for example, the response to the question "Are you worried about the growing amount of waste?" is used for recycling behavior c For b = 2–9 it is a 0–1 dummy variable, set to 0 if the respondent is not concerned and 1 otherwise. For b = 1 it is a 0–5 scale corresponding to the amount of environmental concerns expressed by the respondent (set to a maximum of 5 in accordance with the survey design).
$HIGHRESP_{(i)}$	0–1 dummy variable measuring whether the individual ascribes completely to personal responsibility for caring about the environment. It is set to 0 if the respondent does not and 1 otherwise.
$MEDIUMRESP_{(i)}$	0–1 dummy variable measuring whether the individual accepts a medium level of personal responsibility for caring about the environment. It is set to 0 if the respondent does not and 1 otherwise.
$NORESP_{(i)}$	0–1 dummy variable measuring whether the individual rejects entirely personal responsibility for caring about the environment. It is set to 0 if the respondent does not and 1 otherwise.
	External conditions variables
$ECOINFRA_{(i)}$	0–1 dummy variable measuring whether the individual believes that her city is fulfilling its duty in preserving the environment. It can be considered as a proxy for the availability of green infrastructures at the local level, enabling citizens to behave pro-environmentally (e.g. the presence of recycling bins, public transport and cycling tracks). It is set to 0 if the respondent does not and 1 otherwise.
$BOTTLEBILL_{(c)}$	0–1 dummy variable measuring whether the country[d] c where the individual resides has adopted a container deposit law that organizes the collection of cans and bottles and rewards users with a voucher for fuel or groceries. It primarily represents the availability of a green infrastructure tied to an economic incentive to recycle, but it can also be considered as a proxy for the availability of other green infrastructures (e.g., if a country has adopted it, it may be more likely to have adopted other national-level green infrastructures as well). It is set to 0 if the country where the individual resides has not adopted it and 1 otherwise.
	Hofstede socio-cultural values variables[e]
$POWERDIST_{(c)}$	0–100 index measuring the extent to which the less powerful members in country c accept an unequal distribution of power. The higher it is, the more important are dependence and subordination.
$INDIVID_{(c)}$	0–100 index measuring how loose ties are among individuals in country c. The higher it is, the most important are independence, competition, personal achievement and self-reliance.
$MASCUL_{(c)}$	0–100 index measuring how strongly emotional gender roles are set in country c. The higher it is, the most important are assertiveness, success and achievement.
$LONGTERM_{(c)}$	0–100 index measuring the extent to which members in country c are oriented towards future rewards as opposite to immediate gains, prioritizing saving, persistence and adaptation to changing circumstances.
$INDULG_{(c)}$	0–100 index measuring the extent to which members in country c feel free to pursue subjective happiness and have a sense of control over their own life.
	Socio-Demographic controls
$FEMALE_{(i)}$	0–1 dummy variable capturing whether the individual is female. Set to 0 if the respondent is a male and 1 otherwise.
$AGE_{(i)}$	Continuous variable reporting the respondent's age at the time of the interview.
$EDU_{(i)}$	1–10 index reporting the respondent's age when she/he left full-time education. 1 corresponds to "no full-time education" and 10 to "22 years or more" or "still studying."
$FINPROB_{(i)}$	0–1 dummy variable measuring whether the individual reported problems paying her bills most of the times in the last year. It is set to 0 if the respondent did not and 1 otherwise.
$BOTTLEBILL_{(c)} * FINPROB_{(i)}$	Interaction term between the two dummy variables BottleBill and FinProb. It measures whether the fact of having economic problems and living in a BottleBill country has a positive effect on self-reported PEB. If significant, it would imply that economic incentives are effective in increasing PEB for individuals who are more sensitive to small economic rewards.

Table Notes: A full list of survey questions extracted from the Eurobarometer database and utilized for this model is available in Annex 1.

[a]A list of the environmental norms corresponding to each behavior is available in Annex 2.

[b]The ideal question to measure recognition of a norm would have been "Do you think people should separate waste for recycling?" The question contained in the survey instead, measures whether the individual considers a given behavior a priority. If the individual responds affirmatively, we consider that she/he implicitly acknowledges the behavior as a norm, as something that ought to be done. If the individual responds negatively, it may be that she/he acknowledges the behavior as a norm but does not identify it as 'urgent' or that she does not identify the behavior as something that ought to be done at all. Therefore, there is a possibility, depending on how the respondent interpreted the survey question, that our indicator may underestimate the number of individuals that recognize the norm. On the other hand, the opposite error (inclusion error) would have been worse. We are confident that the individuals who responded affirmatively, are individuals who recognized the norm. At best, the risk is that our estimated parameters for this indicator, that are in all cases, statistically significant, may be slightly underestimated.

[c]A list of the environmental concerns corresponding to each behavior is available in Annex 2.

[d]As of 2014, the year of the Eurobarometer survey, only 11 of the 28 surveyed countries had implemented a Bottle Bill system: Austria, Belgium, Croatia, Cyprus, Denmark, Estonia, Finland, Germany, Hungary, the Netherlands and Sweden. Despite their exclusion from the (Container Recycling Institute, 2016), we decided to include Hungary and Cyprus in the list following evidence reported by (European Parliament, 2011) and (BiPRO/CRI, 2015).

[e]The socio-cultural dimensions identified by Hofstede are six, however, for the sake of this analysis we dropped one, namely "uncertainty avoidance," because of multicollinearity with other variables.

1.5 Results

1.5.1 Relative importance of intrinsic motivation, external conditions and socio-cultural values

Results of the regression performed on the entire dataset are reported in Table 1.2. In regressions (1)–(9), we analyzed the eight PEBs separately, capturing the intuition—supported by Oskamp et al. (1991)— that environmental efforts and attitudes are fractioned into specific components that are peculiar to each behavior; that is, the antecedents of a PEB and their relative importance vary with each behavior. Nevertheless, there may also be findings that are generalizable to most PEBs. The latter are captured in regression (0.a–c), in which the response variable represents the sum of the PEBs adopted by the individual.

As shown by the R^2 values reported in the table, the parameters in the model were successful in explaining 7.9%–20.6% of the variation in the response variable, a level that, given the complexity of human behavior, is considered significant for studies with individual persons as units of analysis and a heterogeneous sample (Langbein, 2015). The checks for collinearity did not reveal near dependencies among the regressors used. Pearson pairwise correlation showed low correlation in all cases with two exceptions. However, all the VIF and Condition Index values were well below the threshold values for multicollinearity of 10 and 30, respectively.

The most notable finding is that, across all the PEBs observed, the estimated parameters for intrinsic motivation—that is, *Norm, HighResp,* and *EnvWorry*—dominate the external factors; they have the highest absolute value among the estimated regressors.[3] All the intrinsic motivation indicators are statistically significant and have the expected sign: recognition of the norm (*Norm*), environmental worry (*EnvWorry*) and personal responsibility (*HighResp*) correlate positively with the dependent variable. The biggest impact is represented by the recognition of the norm, followed by the personal responsibility coefficient.

The relative predominance of intrinsic motivation over external conditions and socio-cultural factors is also demonstrated by pseudo-R^2 values in regression (0.a–c). In (0.a), intrinsic motivation alone accounts for 13.6% of the variation in the response variable.[4] Incrementally adding external conditions

[3] Since all the intrinsic motivation and external conditions variables are dummies, the analysis concerning the magnitude of the estimated coefficients among these variables is straightforward.
[4] The pseudo-R^2 result is 11.9% when excluding demographic control variables.

(regression 0.b) and socio-cultural values (regression 0.c) leads to marginal increases to the pseudo-R^2 values, 14.3% and 17.5% respectively.

External conditions are represented by the EcoInfra and BottleBill, their coefficients are statistically significant and have positive sign in regression (0.b), showing that the presence of green infrastructures and monetary incentives increase the numbers of PEBs adopted. These coefficients change to a non-statistically significant and negative coefficient respectively once socio-cultural values are included (regression 0.c), possibly due to the high correlation between these two classes of variables. In the recycling regression (1), both coefficients are statistically significant with positive sign, suggesting that both green infrastructures and the presence in the country of a container deposit legislation positively affect the probability that individuals will recycle. Additionally, the coefficient for green infrastructures is not statistically significant or has negative sign when the other behaviors are considered in isolation, thus leading to inconclusive results. This shows that the presence of an external apparatus, which facilitates certain PEBs, does not necessarily induce the adoption of other unrelated PEBs, and reflect the fact that some PEBs, such as reducing water and energy use do not depend on green infrastructures.

Financial constraints affect most PEBs negatively with the exception of green traveling, diminished car use and energy and water saving. While it is unsurprising that financially distressed individuals are less likely to purchase green products or energy-saving appliances, which are often more expensive, the negative correlation with income-neutral behaviors, such as recycling, was unexpected. However, it is consistent with the hypothesis that, if an individual is distracted by more pressing personal circumstances, she/he is less likely to act in a norm-consistent way (Cialdini et al., 1990, p. 204). The FinProb coefficient is statistically significant and positive for "reduce water consumption," and "green traveling" which is also expected considering that these behaviors reflect positively in savings. Unex pectedly, the FinProb coefficient is not statistically significant in the "reduce energy consumption." Several European countries have adopted pricing schemes whereby energy tariffs are determined by market prices, which vary depending on the time of the day and the source used, and they generally have an important fixed component that leads to decreasing average prices for the consumer. The user is more likely to control the final bill by changing the usage times rather than by reducing the consumption per se. For example, Filippini (2011) found that households are highly responsive to the changes in off-peak and high-peak energy prices and adapt their energy use accordingly. On the other hand, water tariffs in OECD countries tend to follow constant volumetric pricing, with a growing trend to apply increasing block tariff systems, while the relevance of fixed charges has declined significantly (OECD, 2009). Volumetric pricing schemes, and particularly increasing block tariffs, encourage a reduction in water consumption. Although, as income rises, a volumetric tariff scheme might be an ineffective mean to induce water-saving behavior among richer individuals.

In the second regression for recycling (2), we introduce the interaction term BottleBill*FinProb. The coefficient is statistically significant with a positive sign. This suggests that economic incentives are effective in limiting the negative impact of economic difficulties on PEB. This last point is corroborated by the descriptive statistics from the database (European Commission, 2015) showing that: (i) Overall, individuals with economic problems are much less likely to recycle per se: only 59% of them recycle compared with 73% in the rest of the sample. (ii) However, if an individual with economic problems resides in a Bottle Bill country, she/he is 2 percentage points more likely to recycle her/his trash (60%) than if she/he resides elsewhere (58%).

The five 0–100 indexes of socio-cultural values we included showed that predominant values in societies can explain a meaningful part of PEB adoption rates. Particularly, indulgent societies are more likely to engage in almost any PEB. Individuals living in more long-term oriented societies are also more likely to adopt a higher number of PEBs. They are more likely to adopt any behavior except for reducing water and energy use.

TABLE 1.2 Impact of internal motivation, external factors and socio-cultural values on eight PEBs

	OLS			LOGIT								
	SUM OF ALL PEBS 0–8	**SUM OF ALL PEBS 0–8**	**SUM OF ALL PEBS 0–8**	**RECYCLING**	**RECYCLING**	**WASTE REDUCTION**	**REDUCE WATER USE**	**REDUCE ENERGY USE**	**BUY GREEN PRODUCTS**	**BUY LOCAL PRODUCTS**	**GREENER WAY OF TRAVELING**	**USE CAR LESS**
	0.a	***0.b***	***0.c***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
NORM	1.442*** (0.133)	1.442*** (0.133)	1.392*** (0.131)	1.007*** (0.031)	1.076*** (0.032)	0.476*** (0.035)	0.879*** (0.040)	0.811*** (0.029)	0.884*** (0.036)	1.177*** (0.034)	1.033*** (0.030)	0.543*** (0.034)
ENVWORRY	0.324*** (0.009)	0.320*** (0.009)	0.291*** (0.009)	0.120*** (0.031)	0.198*** (0.032)	0.141*** (0.000)	0.186*** (0.032)	0.157*** (0.030)	0.253*** (0.034)	0.145*** (0.042)	0.091*** (0.031)	0.150*** (0.047)
HIGHRESP	0.602*** (0.021)	0.601*** (0.021)	0.518*** (0.021)	0.391*** (0.019)	0.299*** (0.020)	0.320*** (0.020)	0.264*** (0.019)	0.287*** (0.018)	0.369*** (0.024)	0.251*** (0.020)	0.245*** (0.019)	0.211*** (0.023)
ECOINFRA		0.049** (0.021)	0.012 (0.021)	0.228*** (0.065)	0.182*** (0.032)	-0.070** (0.030)	-0.004 (0.030)	-0.042 (0.029)	-0.183*** (0.034)	-0.046 (0.030)	-0.034 (0.030)	-0.123*** (0.035)
BOTTLEBILL		0.212*** (0.023)	-0.074*** (0.026)	0.065*** (0.032)	-0.353*** (0.041)							
FINPROB		-0.288*** (0.036)	-0.283*** (0.036)	-0.608*** (0.044)	-0.566*** (0.052)	-0.209*** (0.051)	0.165*** (0.046)	0.034 (0.045)	-0.188*** (0.060)	-0.104** (0.048)	0.110*** (0.047)	-0.073 (0.057)
FINPROB * BOTTLEBILL		0.133* (0.077)	0.281*** (0.077)		0.257** (0.110)							
POWERDIST			-0.005*** (0.001)		0.002** (0.001)	-0.006 (0.004)	0.006 (0.004)	0.000 (0.004)	-0.006 (0.004)	-0.007* (0.004)	0.005 (0.004)	0.001 (0.004)
INDIVID			0.003* (0.001)		0.005*** (0.001)	-0.020*** (0.005)	-0.003 (0.005)	-0.001 (0.005)	-0.011* (0.006)	-0.007 (0.005)	-0.001 (0.005)	-0.012** (0.006)
MASCUL			0.002*** (0.000)		0.004*** (0.001)	0.008*** (0.003)	0.000 (0.003)	-0.006** (0.003)	-0.001 (0.003)	-0.007** (0.003)	-0.012*** (0.003)	-0.004 (0.003)
LONGTERM			0.005*** (0.001)		0.005*** (0.001)	0.010*** (0.003)	0.001 (0.003)	0.003 (0.003)	0.012*** (0.004)	0.007** (0.004)	0.006* (0.004)	0.011*** (0.004)
INDULG			0.017*** (0.001)		0.034*** (0.001)	0.018*** (0.005)	0.018*** (0.005)	0.018*** (0.004)	0.025*** (0.005)	-0.002 (0.005)	0.015*** (0.005)	0.030*** (0.005)
FEMALE	0.242*** (0.021)	0.255*** (0.021)	0.277*** (0.021)	0.128*** (0.031)	0.175*** (0.032)	0.208*** (0.030)	0.267*** (0.029)	0.204*** (0.028)	0.314*** (0.034)	0.234*** (0.029)	0.197*** (0.029)	-0.188*** (0.034)
AGE	0.009*** (0.001)	0.007*** (0.001)	0.006*** (0.001)	0.011*** (0.001)	0.010*** (0.001)	0.005*** (0.001)	0.009*** (0.001)	0.005*** (0.001)	0.000 (0.001)	0.008*** (0.001)	-0.005*** (0.001)	-0.002** (0.001)
EDU	0.058*** (0.004)	0.046*** (0.004)	0.047*** (0.004)	0.041*** (0.006)	0.045*** (0.006)	0.044*** (0.006)	0.004 (0.006)	0.040*** (0.006)	0.089*** (0.007)	0.063*** (0.006)	0.042*** (0.006)	0.040*** (0.007)
RURAL											-0.133*** (0.037)	-0.148*** (0.045)
COUNTRY FIXED EFFECTS	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
PSEUDO R^2	0.136	0.143	0.175	0.127	0.206	0.109	0.119	0.115	0.183	0.173	0.143	0.079
F-TEST/ -2 LOG LIKELIHOOD	529.176	358.273	306.231	25709.949	24231.579	27130.916	28319.956	29929.788	22353.527	27725.687	27950.623	22373.026
NO. OF OBS.	23,516	23,516	23,087	23,107	23,107	23,088	23,088	23,088	23,088	23,088	23,088	23,088

Notes: Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.10. For regressions (1)–(10), the Nagelkerke R2 and McFadden —2 log likelihood are reported. Equation (0) shows an adjusted R2 and F-test of overall significance.

Both findings are expected since more indulgent societies are usually linked to a greater sense of control (Hofstede & Minkov, 2010), which can instill a greater sense of responsibility; and caring for the environment implies the ability to take into consideration future consequences. In individualist societies, people are less likely to reduce car use, purchase green label products and reduce waste.Additionally, socio-demographic controls show the following. Being a female correlates positively with all the PEBs with the exception of "use car less," suggesting that women are more likely to adopt any PEBs except renouncing to drive their car. This finding is supported in the literature on altruistic behavior, such as PEBs, which finds that women are more likely to engage in other-regarding behavior (Hunter et al., 2004; Kollmuss & Agyeman, 2002) and hold more pro-environmental attitudes (Dietz et al., 1998; Vaske et al., 2001). Age correlates positively with all the PEBs observed except for green traveling and reduced car use, suggesting that older people are in general more observant of environmental norms, except when it comes to considering alternatives to their own car. Predictably, the level of education also increases engagement in nearly all the PEBs, except for water saving.

1.5.2 Clustering individuals by level of responsibility ascription

Table 1.3 summarizes the estimated results for the same model with the exception that survey respondents were divided into clusters. Logit split regressions are performed on three groups clustered by their level of personal ascription of responsibility for preserving the environment (a equals to high responsibility, b to medium responsibility and c to no responsibility at all). The three regressions are performed on three PEBs that differ in the way in which they affect income: (1) recycling (income neutral); (2) water saving (income positive); and (3) purchase of green-label products (income negative).

The rationale is to assess whether people with differing levels of ascription of responsibility react differently to external conditions and whether changes apply to different kinds of PEB, as defined by their effect on income. The regressions include country fixed effects and social values indicators. The regressions for recycling, however, are also computed including BottleBill but excluding country and social values controls due to collinearity with this variable (Equation 1.a2–1.c2).

Recognition of the norm (*Norm)* is the most important factor across groups and behaviors (statistically significant coefficient and greatest in magnitude). In all three behaviors, the coefficient for EnvWorry is not statistically significant for the NoResp group. This would suggest that, without a minimum level of ascription of responsibility, environmental concern alone is not conducive to adopting PEB.

The availability of "green infrastructures"—captured by EcoInfra— is relevant only to high/medium levels of ascription of responsibility, the coefficient is not statistically significant in the regressions for the NoResp group. This implies that, without a minimum level of motivation, green infrastructures alone are not effective. Green infrastructures appear to negatively affect green label purchases for medium/ high levels of responsibility, a result of difficult interpretation. Container deposit schemes for used bottles positively impact recycling rates—the BottleBill coefficient is statistically significant with positive sign—but only for the HighResp group (Equation 1.a2–1.c2).

TABLE 1.3 Impact of external conditions on three PEBs conditional on the degree of internal motivation

	RECYCLING 1						REDUCE WATER USE 2			BUY GREEN PRODUCTS 3		
	HIGH RESP (A)	MID RESP (B)	NO RESP (C)	HIGH RESP (A.2)	MID RESP (B.2)	NO RESP (C.2)	HIGH RESP (A)	MID RESP (B)	NO RESP (C)	HIGH RESP (A)	MID RESP (B)	NO RESP (C)
NORM	0.946*** (0.054)	1.113*** (0.044)	1.379*** (0.164)	0.860*** (0.047)	1.033*** (0.038)	1.423*** (0.139)	0.795*** (0.062)	0.910*** (0.055)	1.243*** (0.212)	0.736*** (0.050)	1.034*** (0.053)	1.486*** (0.245)
ENVWORRY	0.137*** (0.054)	0.181*** (0.044)	0.027 (0.162)	0.090** (0.047)	0.153*** (0.038)	0.069 (0.139)	0.123*** (0.047)	0.252*** (0.045)	0.204 (0.187)	0.270*** (0.047)	0.231*** (0.050)	0.333 (0.232)
BOTTLEBILL				0.080* (0.049)	0.024 (0.040)	-0.014 (0.141)						
ECOINFRA	0.121** (0.055)	0.045 (0.045)	0.171 (0.166)	0.280*** (0.048)	0.188*** (0.038)	0.304** (0.139)	0.025 (0.044)	-0.028 (0.041)	-0.046 (0.176)	-0.253*** (0.049)	-0.117** (0.050)	-0.224 (0.242)
FINPROB	-0.377** (0.080)	-0.334*** (0.068)	-0.253 (0.223)	-0.592*** (0.068)	-0.611*** (0.058)	-0.574*** (0.184)	0.116* (0.069)	0.206*** (0.065)	0.134 (0.236)	-0.164** (0.082)	-0.245*** (0.092)	-0.271 (0.346)
FEMALE	0.196*** (0.053)	0.196*** (0.053)	-0.067 (0.164)	0.244*** (0.047)	0.086** (0.038)	0.139 (0.139)	0.288*** (0.043)	0.242*** (0.041)	0.461*** (0.174)	0.373*** (0.048)	0.258*** (0.050)	0.463* (0.237)
AGE	0.011*** (0.002)	0.011*** (0.002)	0.000 (0.005)	0.013*** (0.001)	0.013*** (0.001)	0.003 (0.003)	0.009*** (0.001)	0.009*** (0.001)	0.001 (0.005)	0.002 (0.002)	-0.003** (0.002)	-0.002 (0.007)
EDU	0.055*** (0.011)	0.055*** (0.011)	0.023 (0.032)	0.029*** (0.008)	0.042*** (0.097)	0.023 (0.024)	-0.003 (0.009)	0.014* (0.008)	-0.013 (0.034)	0.087*** (0.010)	0.093*** (0.010)	0.088*** (0.046)
SOCIAL VALUES CONTROLS	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y
COUNTRY FIXED EFF.	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y
OBS	10816	12192	881	10816	13400	1008	10027	12192	881	10027	12192	881
R-SQUARED	0.245	0.255	0.313	0.050	0.064	0.103	0.101	0.121	0.194	0.175	0.153	0.187
P>CHI2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LOG-LIKELIHOOD	9092.293	12884.654	985.472	-5603.9995	-7962.3422	-626.099	12828.016	14507.877	905.310	11033.685	10661.343	557.204

Notes: Standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.10. The Nagelkerke R2 and McFadden 2 log likelihood are reported at the end of the table. Equation (1.a2)–(1.c2) excludes social values indicators and country fixed effects due to collinearity with BottleBill.

1.6 Conclusions

This article used a cross-country dataset to empirically investigate the reason behind different PEB adoption rates across the EU. To do so, our empirical model, based on survey data of 28,000 individuals across the EU's 28 member states (in 2018), assessed the relative strength of predominant socio-cultural values, intrinsic motivation and green infrastructures on eight self-reported PEBs.

PEB depends on all the three classes of factors analyzed. However, we find that intrinsic motivation—mostly internalized environmental norms, but also awareness of environmental consequences and ascription to personal responsibility towards the environment—is the leading force behind the eight PEBs considered. This finding is consistent across the eight PEBs examined and it is consistent with conclusions in Cecere et al. (2014). Consequently, since intrinsic motivation varies widely across the countries analyzed, diverging outcomes in the EU can be mainly attributed to differences in the level of intrinsic motivation in its national populations and to heterogenous responses to the same policy.

In particular, ascription of responsibility appears to be an essential precondition for an individual to respond positively to external incentives, for example, being less prone to negative influences (such as economic constraints) and more receptive to enabling conditions (such as the availability of economic rewards or green infrastructures). This finding highlights a potential limit for the effectiveness of external conditions: they can only be effective in promoting PEB among individuals who have a minimum level of intrinsic motivation.

Based on our results we advise that policy makers should start by assessing the level of intrinsic motivation—specifically ascription of personal responsibility and recognition of the environmental norm— for a given behavior in their target population. These data are regularly surveyed within EU (Eurobarometer) and elsewhere, and they include reports with summary statistics. If these average values are low or if a consistent proportion of individuals rejects any environmental responsibility; the policy should focus primarily on increasing both responsibility ascription and norm recognition. Policy makers should, however, be conscious that changing intrinsic motivation is a long-term goal (Thøgersen & Ölander, 2002).

There are, however, other policy avenues that can increase PEB adoption rates in the shorter term and that can run in parallel with the long-term objectives mentioned above. If the target population is highly motivated but norm observance is low, it may be an indication that interventions should focus on facilitating the behavior financially, physically or socially.

Influencing social norms: National level socio-cultural values are the second factor affecting PEB. Social values and norms influence behavior indirectly, by influencing the norms that individuals internalize, but also directly through compliance with what individuals perceive as social expectations. While cultural values are hard to change, ample evidence supports that social norms can be influenced. Norm nudges are behavioral interventions aimed at changing social expectations. They can induce shifts in behavior by changing what people think others will do or approve of (Bicchieri and Mercier, 2014).

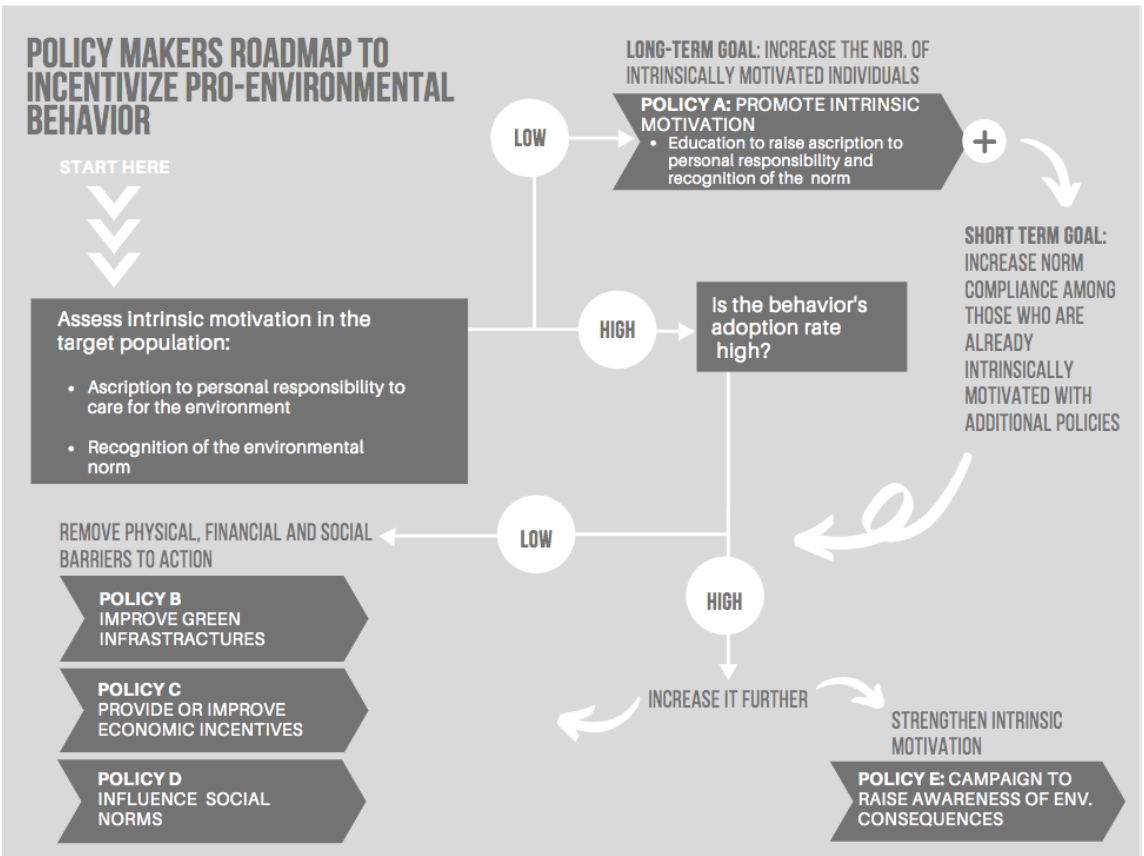
Using economic incentives: Monetary rewards to recycle proved to be effective to increase recycling rates, particularly for highly motivated individuals and for financially strained ones. We observed that financially distressed individuals are less likely to adopt PEBs that imply higher costs (such as buying green label products) or that are cost neutral (such as recycling); but that they are more likely to engage in PEBs when they imply clear cost savings (such as reducing water usage) or rewards (such as returning empty vessels to container deposit collection schemes). Reframing the choice context into economic terms—by attaching an economic value to the behavior—appeared to be successful in raising the observance of the environmental norm in this group.

Beyond providing economic incentives, policy makers should analyze the pre-existing ones. Pricing schemes of water and energy utilities can discourage excessive consumption through volumetric pricing

schemes or increasing block tariffs. Conversely, with contracts that offer market-prices, the user is more likely to try to reduce the final bill by using electricity at off-peak times rather than by diminishing total usage.5[5] As another example, individuals may refrain from energy-efficiency investments, even when is it economically convenient to do so in the long-run, for lack of financial means. Financing schemes that highlight the economic benefits of energy-efficiency investments would extend this opportunity to more people.

Providing or improving infrastructure: Some behaviors—such as reducing water and energy consumption—do not need green infrastructures to be carried out, while others are highly dependent on the availability of safe biking lanes, recycling bins, and so forth. Green infrastructures increase the number of PEBs adopted for this latter group and it can increase adoption rates among individuals that are already motivated. They are, however, less likely to be effective on those who do not ascribe to at least a minimal level of responsibility for the environment. Strengthening intrinsic motivation: Individuals that recognize the moral norm related to the behavior—for example, "One should reduce car use"—and that ascribe to responsibility for the state of the environment become more likely to perform the behavior if they are also aware of the consequences of not performing it—for example, bad air quality, congestion and GHGs emissions. Information campaigns targeting this aspect will not, however, be effective on individuals that do not ascribe to any personal responsibility for the environment. The flowchart below summarizes these steps (Figure 1.6).

FIGURE 1.6 Policy makers roadmap to incentivize pro-environmental behavior



Source: Produced by the authors

[5] A related future research topic could be aimed at clarifying whether it is more environmentally beneficial to smooth energy consumption through off peak-times or to just diminish total usage, given different compositions of the energy source mix.

The considerations above lead us to conclude that raising intrinsic motivation should in the long term decrease the number of non-intrinsically motivated individuals—that is, defectors—, while progressively extending the effectiveness of the other policy tools to a broader portion of the target population. Consequently, the ideal approach should combine long-term educational efforts with short/ medium-term policies aimed at facilitating PEB materially and socially. The main limitation in this study is linked to data availability. The lack of municipal level data regarding the different green infrastructures in Europe obliged us to rely on proxies. The development of a coherent database of green infrastructures in Europe in the future would offer a chance to refine the analysis. To date, no comprehensive research has been undertaken on the impact of economic problems on PEB. Future research avenues may include an overview of how PEBs' observance rates have evolved since the beginning of the Great Recession and a study on the conditions and extent to which individuals trade environmental and economic priorities.

1.7 References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 25, 273–291.

Arkesteijn, K., & Oerlemans, L. (2005). The early adoption of green power by Dutch households: An empirical exploration of factors influencing the early adoption of green electricity for domestic purposes. Energy Policy, 33, 183–196.

Attari, B. S. Z., Dekay, M. L., Davidson, C. I., & de Bruin, W. B. (2011). Changing household behaviors to curb climate change: How hard can it be ? Sustainability, 4(1), 9–11.

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro- environmental behaviour. Journal of Environmental Psychology, 27(1), 14–25.

Beretti, A., Figuières, C., & Grolleau, G. (2019). How to turn crowding- out into crowding-in? An innovative instrument and some law- related examples. European Journal of Law and Economics volume. 48, 417–438. https://doi.org/10.1007/s10657-019-09630-9

Bicchieri, C., & Mercier, H. (2014). Norms and beliefs: How change occurs. In M. Xenitidou & B. Edmonds (Eds.), The complexity of social norms (pp. 37–54). Springer International Publishing.

BiPRO/CRI. (2015). Assessment of separate collection schemes in the 28 capitals of the EU—National factsheet Hungary. https://www.municipalwasteeurope.
eu/sites/default/files/HU%20National%20factsheet.pdf

Black, J. S. (1978). Attitudinal, normative, and economic factors in early responses to an energy-use field experiment (Vol. 1). University of Wisconsin.

Black, S., Stern, P., & Elworth, J. (1985). Personal and contextual influences on household energy adaptations. Journal of Applied Psychology, 70(1), 3–21.

Cecere, G., Mancinelli, S., & Mazzanti, M. (2014). Waste prevention and social preferences: The role of intrinsic and extrinsic motivations. Ecological Economics, 107, 163–176.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. Journal of Personality and Social Psychology, 58(6), 1015–1026.

Container Recycling Institute. (2016). BottleBill.org—Worldwide. Retrieved May 5, 2016, from http://www.bottlebill.org/legislation/world.htm

Cordano, M., Welcomer, S., Scherer, R. F., Pradenas, L., & Parada, V. (2011). A cross-cultural assessment of three theories of pro- environmental behavior: A comparison between business students of Chile and the United States. Environment and Behavior, 43, 634–657.

De Young, R. (1985). Encouraging environmentally appropriate behavior: The role of intrinsic motivation. Journal of Environmental Systems, 15(4), 281–292.

Derksen, L., & Gartrell, J. (1993). The social context of recycling. American Sociological Review, 58(3), 434–442.

Dietz, T., Stern, P. C., & Guagnano, G. A. (1998). Social structural and social psychological bases of environmental concern. Environment and Behavior, 30(4), 450–471.

European Commission. (2015). Eurobarometer 81.3 (2014). TNS Opinion, Brussels [Producer]. GESIS Data Archive.

European Environment Agency. (2017). Waste recycling. Retrieved February 23, 2018, from https://www.eea.europa.eu/data-and-maps/ indicators/waste-recycling-1/assessment

European Parliament. (2011). A European refunding scheme for drinks containers. Directorate general for external policies. http://www.europarl. europa.eu/RegData/etudes/note/join/2011/457065/IPOL-AFET_NT (2011)457065_EN.pdf

Fehr, E., & Gintis, H. (2007). Human motivation and social cooperation: Experimental and analytical foundations. Annual Review of Sociology, 33(1), 43–64.

Ferrara, I., & Missios, P. (2005). Recycling and waste diversion effectiveness: Evidence from Canada. Environmental & Resource Economics, 30(2), 221–238.

Ferrara, I., & Missios, P. (2012). A cross-country study of household waste prevention and recycling: Assessing the effectiveness of policy instruments. Land Economics, 88(4), 710–744.

Filippini, M. (2011). Short and long-run time-of-use price elasticities in Swiss residential electricity demand (Working Paper No. 76).

Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and why incentives (don't) work to modify behavior. Journal of Economic Perspectives, 25(4), 191–210.

Grodzińska-Jurczak, M. (2003). The relation between education, knowledge and action for better waste management in Poland. Waste Mangement & Research, 21(1), 2–18.

Guagnano, G. A., Stern, P. C. P., & Dietz, T. (1995). Influences on attitude-behavior relationships: A natural experiment with curbside recycling. Environment and Behavior, 27(5), 699–718.

Heberlein, T. A. (1981). Environmental attitudes. Zeitschrift fur Umweltpolitik, Journal of Environmental Policy, 81(2), 241–270.

Heller, M. H., & Vatn, A. (2017). The divisive and disruptive effect of a weight-based waste fee. Ecological Economics, 131, 275–285.

Hofstede, G. J. (2015). Six dimension of culture by country—Data matrix. Retrieved February 27, 2018, from http://geerthofstede.com/research-and-vsm/dimension-data-matrix/

Hofstede, G. J., & Minkov, M. (2010). Cultures and Organizations: Softwareof the mind (Rev. 3rd ed.). McGrawHill.

Hopper, J., & Nielsen, J. (1991). Recycling as altruistic behavior: Normative and behavioral strategies to expand participation in a community recycling program. Environment and Behavior, 23, 195–220.

Humphrey, C. R., Bord, R. J., Hammond, M. M., & Mann, S. H. (1977). Attitudes and conditions for cooperation in a paper recycling program. Environment and Behavior, 9(1), 107–124.

Hunter, L. M., Hatch, A., & Johnson, A. (2004). Cross-national gender variation in environmental behaviors. Social Science Quarterly, 85(3), 677–694.

Jackson, T. (2005). Motivating sustainable consumption. Sustainable Development Research Network.

Jacobs, H. E., & Bailey, J. S. (1983). Evaluating participation in a residential recycling program. Journal of Environmental Systems, 12(2), 141–152.

Katzev, R., & Pardini, A. (1987). The comparative effectiveness of reward and commitment approaches in motivating community recycling. Journal of Environmental Systems, 17, 93–113.

Kirakozian, A. (2016). One without the other? Behavioural and incentive policies for household waste management. Journal of Economic Sureys, 30(3), 526–551.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? Environmental Education Research, 8(3), 239–260.

Langbein, L. (2015). Public program evaluation: A statistical guide (first). Routledge.

Linderhof, V., Kooreman, P., Allers, M., & Wiersma, D. (2001). Weight-based pricing in the collection of household waste. Resource and Energy Economics, 24(4), 359–371.

Liobikienė, G., Mandravickaitė, J., & Bernatonienė, J. (2016). Theory of planned behavior approach to understand the green purchasing behavior in the EU: A cross-cultural study. Ecological Economics, 125, 38–46.

OECD. (2009). Managing water for all: An OECD perspective on pricing and financing. OECD.

Onwezen, M. C., Antonides, G., & Bartels, J. (2013). The norm activation model: An exploration of the functions of anticipated pride and guilt in pro-environmental behaviour. Journal of Economic Psychology, 39, 141–153. https://doi.org/10.1016/j.joep.2013.07.005

Oskamp, S., Harrington, M. J., Edwards, T. C., Sherwood, D. L., Okuda, S. M., & Swanson, D. C. (1991). Factors influencing household recycling behavior. Environment and Behavior, 23(4), 494–519.

Palmer, K. L., & Walls, M. A. (1997). Optimal policies for solid waste disposal: Taxes, subsidies, and standards. Journal of Public Economics, 65(2), 193–205.

Schneider, J., Karigl, B., Reisinger, H., Oliva, J., Sübenbacher, E. & Read, B. (2011). A European refunding scheme for drinks containers. https:// www.europarl.europa.eu/RegData/etudes/note/join/2011/457065/ IPOL-AFET_NT(2011)457065_EN.pdf

Schwartz, S. (1968). Awareness of consequences and the influence of moral norms on interpersonal behavior. Sociometry, 31(4), 355–369.

Schwartz, S. (1977). Normative influences on altruism. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 10, pp. 221–279). Academic Press.

Sidique, S. F., Joshi, S. V., & Lupi, F. (2010). Factors influencing the rate of recycling: An analysis of Minnesota counties. Resources, Conservation and Recycling, 54(4), 242–249.

Stern, P. C., Dietz, T., & Black, J. S. (1985). Support for environmental protection: The role of moral norms. Population and Environment, 8(3-4),204–222. https://doi.org/10.1007/bf01263074

Thøgersen, J. (1994). Monetary incentives and environmental concern.Effects of a differentiated garbage fee. J Consum Policy, 17, 407–442.https://doi.org/10.1007/BF01022912

Thøgersen, J. (1996). Recycling and morality: A critical review of the literature. Environment and Behavior, 28, 536–558. https://doi.org/10.1177/0013916596284006

Thøgersen, J. (2003). Monetary incentives and recycling: Behavioural and psychological reactions to a performance-dependent garbage fee. Journal of Consumer Policy, 26, 197–228. https://doi.org/10.1023/A: 1023633320485

Thøgersen, J., & Ölander, F. (2002). Human values and the emergence of a sustainable consumption pattern: A panel study. Journal of Economic Psychology, 23, 605–630.

Turaga, R. M. R., Howarth, R. B., & Borsuk, M. E. (2010). Pro- environmental behavior: Rational choice meets moral motivation. Annals of the New York Academy of Sciences, 1185, 211–224.

van den Bergh, J. C. J. M. (2008). Environmental regulation of households: An empirical review of economic and psychological factors. Ecological Economics, 66(4), 559–574.

Vaske, J. J., Donnelly, M. P., Williams, D. R., & Jonker, S. (2001). Demographic influences on environmental value orientations and normative beliefs about national forest management. Society and Natural Resources, 14, 761–776.

1.8 Appendix

1.8.1 Annex 1 – List of Eurobarometer's attitudinal survey questions included

Survey question: ***QA2. From the following list, please pick the five main environmental issues that you are worried about.***

Answer options (max. 5 answers, 16 and 17 are exclusive):

1. The depletion of natural resources
2. Our consumption habits
3. The growing amount of waste
4. Loss or extinction of species and their habitats and of natural ecosystems (forests, fertile soils)
5. Shortage of drinking water
6. Water pollution (seas, rivers, lakes and underground sources)
7. Agricultural pollution (use of pesticides, fertilizers, etc.)
8. Soil degradation
9. Land take (i.e. that more land is used to build roads or cities and that cities expand into the surrounding countryside)
10. The impact on our health of chemicals used in everyday products
11. Air pollution
12. Noise pollution
13. Urban problems (traffic jams, pollution, lack of green spaces, etc.)
14. The spread of harmful non-native plants and animals (invasive species)
15. Other
16. None
17. Don't know

Use in the analysis: used to create explanatory variable *EnvWorry*.

Survey question: ***QA11. Have you done any of the following for environmental reasons in the past month?***

Answer options (multiple answers possible, 10 and 11 are exclusive):

1. Chosen a more environmentally friendly way of traveling (by foot, bicycle, public transport)
2. Reduced waste, for example by avoiding over-packaged products and buying products with a longer life
3. Separated most of your waste for recycling
4. Cut down your water consumption
5. Cut down your energy consumption, for example by turning down air conditioning or heating, not leaving appliances on stand-by, buying energy efficient appliances
6. Bought environmentally friendly products marked with an environmental label
7. Chosen local products
8. Used your car less
9. Other
10. None
11. Don't know

Use in the analysis: used to create response variable *PEB*.

Survey question: ***QA12. In your opinion, which of these should be the top-three priorities for people in (OUR COUNTRY) in their daily life to protect the environment?***

Answer options (max. 3 answers, 12 and 13 are exclusive):

1. Use public transport as much as possible instead of using your own car
2. Replace your car with a more energy-efficient one, even if it is smaller or more expensive
3. Purchase environmentally friendly products for your daily needs
4. Reduce food waste through smarter purchasing, storage, preparation and use of leftovers
5. Sort waste so that it can be recycled
6. Reduce waste, for example by avoiding over-packaged products and buying products with a longer life
7. Reduce your home energy consumption (lighting, heating, household appliances)
8. Consider environmental aspects when you make large purchases (e.g. travelling, heating systems, build a house, etc.)
9. Buy more local products and avoid products that come from far away

10. Reduce water consumption at home
11. Other
12. None
13. Don't know

Use in the analysis: used to create explanatory variable *Norm*.

Survey question: ***QA13.1 Please tell me to what extent you agree or disagree with each of the following statements: as an individual, you can play a role in protecting the environment in (OUR COUNTRY)***

Answer options (one answer):

1. Totally agree
2. Tend to agree
3. Tend to disagree
4. Totally disagree
5. Don't know

Use in the analysis: used to create explanatory variable *HighResp (=1), MedResp(=2,3), NoResp (=4)*.

Survey question: ***QA16.3 In your opinion, is each of the following currently doing too much, doing about the right amount or not doing enough to protect the environment? Your city, town or village***

Answer options (one answer):

1. Doing too much
2. Doing about the right amount
3. Not doing enough
4. Don't know

Use in the analysis: used to create explanatory variable *EcoInfra*.

1.8.2 Annex– Matrix of environmental norms and worries linked to each PEB

The table below summarizes the environmental norms and worries that we considered for each PEB in the econometric analysis. Individual values were obtained from the answers to survey questions QA11, QA12 and QA2.

Table 5. Matrix of environmental norms and worries linked to each PEB

Equation no. in Tables 1 and 2	PEB (question QA11)	Norm (question QA12)	EnvWorry (question QA2)
1	Sum of the 8 PEBs	At least one of the norms listed below.	Sum of all worries, scale 0–5.
2	Waste separation for recycling	Sort waste so that it can be recycled	The growing amount of waste
3	Reduce household waste	Reduce waste, for example by avoiding over-packaged products and buying products with a longer life	The growing amount of waste
4	Reduce water consumption (domestic)	Reduce water consumption at home	Shortage of drinking water
5	Reduce energy consumption (domestic)	Depletion of natural resources	Reduce your home energy consumption (lighting, heating, household appliances)

2

Reversing impatience: Framing mechanisms to increase the purchase of energy-saving appliances

Abstract

Most environmental decisions involve intertemporal trade-offs, in that they require foregoing immediate gratification for the sake of future environmental quality. One such example is investing in energy efficiency, which entails an initial upfront cost in exchange for a future stream of energy and economic savings. Our experiment explores the role of individual temporal preferences in the decision to invest in energy conservation. We report results from a study on a nationally-representative sample of 2010 United States adults. Participants chose between appliances that differed solely in price and operating costs. We manipulated the salience of energy costs and primed participants with future-oriented messages. Our treatments increased energy-efficient choices by 24 percentage points compared with the status-quo scenario. Present-oriented individuals are less likely to purchase energy-efficient appliances but loss-framed messages that highlight the opportunity cost of inefficient appliances diminish the effect of impatience on refrigerators choice.

Keywords

intertemporal choice, energy-efficiency, temporal preferences, pro-environmental behavior, survey experiment, nudge

2.1 Introduction

The majority of individuals do not invest in energy efficiency even when the long-run economic benefits outweigh the upfront additional costs of the initial investment (Schubert and Stadelmann, 2015), a paradox known as the energy-efficiency gap. The societal relevance of the missed potential energy savings is threefold: It represents long-term loss of available income for households,[6] it contributes to global warming,[7] and it negatively affects public health.[8]

We investigate energy investments as a type of temporal dilemma since they require individuals to pay a larger sum immediately in order to enjoy a larger stream of economic savings in the future. In particular, we examine whether individuals can be induced to act more patiently and choose energy efficient devices through framing messages that highlight the opportunity costs of choosing less efficient electric appliances. We further investigate the role of individual temporal preferences in energy investment decisions and whether their impact on choice can be influenced through changes in the choice context. Temporal preferences, the tendency of individuals to be either focused more on the present or on the future, are an underexplored dimension in the literature on energy conservation. By definition, present-oriented individuals discount future well-being at a higher rate; therefore, we expect them to be less likely to invest in energy-saving appliances, since that typically involves a higher price paid today and lower electricity bills over the lifetime of the appliance.

The literature on the energy-efficiency gap has identified the underlying causes of the under-adoption of energy-saving appliances: limited information, cognitive biases, financial constraints, attention deficits, preferences for other appliance attributes, uncertainties about future energy savings, and individual time preferences (DEFRA, 2010; Epper et al., 2011; Newell and Siikamäki, 2015; Allcott and Taubinsky, 2015; Gerarden et al., 2015; Schubert and Stadelmann, 2015). The majority of empirical studies have focused on information and cognitive deficits (Schubert and Stadelmann, 2015), but their experimental treatments reached mixed results and interventions which, at best, yielded only modest efficiency increases (OECD, 2017). Policy measures focused on information and training typically have reached energy savings of about 2% (Rivas et al., 2016). In this paper, we focus on individual time preferences and explore whether their effect on choice can be influenced to induce greater energy savings beyond simple information provisions.

When an inefficient appliance is purchased because the individual is inattentive to or incapable of computing future operating costs, displaying this information alongside the product price can effectively help increase energy-efficient purchases. However, when the reason for such a purchase is that individuals have present-oriented time preferences, displaying such information per se will not produce any effect (DEFRA, 2010). Enzler (2013), Newell and Siikamäki (2015) and Schleich et al. (2019) have found that present-oriented time preferences are associated with higher discounting of future energy savings. Yet, the role of pure time preferences and the extent to which they can be influenced to help close the energy-efficiency gap have not been fully explored.

In this paper, we report results from a sample consisting of 2010 United States (US) adults. Participants were subjected to randomized treatments showing alternative framings of two refrigerators' energy requirements. Our core treatments display information regarding the energy consumed by each refrigerator in either i) kWh/year; ii) estimated electricity cost in US$ over the lifetime of the appliance; or iii) estimated electricity cost in US$ over the lifetime of the appliance with the addition of a message warning about the comparative future economic loss (or gain) compared to the alternative. With the scope of testing the power of our treatments in a more realistic choice environment, where a richer array of appliance attributes beyond purchase price and electricity consumed are listed, we repeat our core

[6] Granade et al. (2009) estimated the energy-efficiency gap in the United States economy to be worth $1.2 trillion in potential energy savings against an upfront capital cost of $520 billion.
[7] Electricity and heat generation from fuel combustion are currently the largest sources of CO_2 emissions from fuel combustion globally (42% of the total in 2016, according to the International Energy Agency, 2021).
[8] Particle pollution from burning fossil fuels for electricity generation in the United States contributes to nearly 15,000 premature deaths a year (Goodkind et al., 2019).

treatments by adding refrigerator images, total and freezer capacity, and color finish specifications to the choice cards. The purpose is to test whether our core treatments are equally effective even when this additional information on the choice cards is competing for the participants' attention. These differences, which are marginal and such that the participant should be indifferent to them, are randomly assigned to either the more or the less efficient appliance.

Performing a randomized experiment enables us to infer any causality nexus between the treatment and the resulting outcomes. This is because the experimental setting allows us to control the exact choice context and because the sample of participants in each group can be assumed to be homogeneous, thanks to full randomization. In addition, regression analysis helps us to control for other sources of individual heterogeneity which may affect the results.

To date and to the best of our knowledge, no study has focused on the temporal salience of operating costs relative to the capital costs. Nor has the choice context been explicitly framed as one between two sequences: one that promises long-term energy savings in exchange for a price premium paid in the present and one that grants immediate economic savings which are offset in the long term through higher energy consumption. This framing effect has never been tested in an environmental product choice context, nor has its effect been tested on individual temporal preferences. We show that the number of energy-efficient appliances chosen increases as a consequence of this framing.

The remainder of the paper is organized as follows: Section 2 synthesizes the most relevant empirical studies to date; Section 3 describes the data and methods; 4 Results, 5 Discussion show and discuss results; and Section 6 concludes with key messages and policy implications.

2.2 Literature review

There is an abundant body of literature, starting in the 1980s, that has measured how individuals supposedly trade off upfront capital and future operating costs by deriving implicit discount rates from purchase choices. These observed discount rates are typically much higher than the interest rate individuals would be charged for borrowing capital, to the extent that they have been deemed “irrationally high” (Hausman, 1979). Implicit discount rates obtained in this way vary widely across appliance categories, from 7% to 17% for lightbulbs to 39%–300% for refrigerators (Schubert and Stadelmann, 2015). However, such discount rates may reflect considerations beyond cost optimization, for example, risk or uncertainty aversion—i.e., to the fact that the future savings from electricity may actually not materialize, the inability to finance the purchase of the more efficient appliance, or preference for other appliance attributes such as dimensions or appearance as shown in Fig. 2.1. Hence, these discount rates cannot be considered as reflecting pure temporal preferences (Gerarden et al., 2015). In addition, a number of deviations from the expectations of neoclassical economics have been found to influence energy efficiency choices, including status-quo bias, present bias myopia or bounded rationality (Cattaneo, 2019). Therefore, a number of interesting questions remain unanswered, such as: What is the contribution of pure time preferences to the energy-efficiency gap? To what extent does myopic preferences drive these abnormally high discount rates? Can we influence energy-saving product choices by manipulating label information on the salience of intertemporal costs and benefits?

Research has shown that individuals largely ignore ancillary costs (such as maintenance or operating costs) when making investment decisions (Allcott and Wozny, 2014; DEFRA, 2010). Half of vehicle buyers admit to not considering fuel costs in their purchase decisions (Allcott, 2011), and buyers often disregard the price of ink cartridge replacements when purchasing a printer (Hall, 1997). Individuals are also unable to estimate the energy usage of their appliances and the costs associated (Attari et al., 2010; Epper et al., 2011). Even when salient to the buyer, information regarding the running costs of energy-efficient appliances can be hard to process (OECD, 2017). Most energy labels, such as the European Union's energy-efficient rating system, indicate the efficiency of the appliance relative to similarly sized counterparts and estimated annual kWh consumption (Rohling and Schubert, 2013). Evidence from experimental studies, however, shows that consumers focus mostly on the former. This can induce buyers into the “energy-efficiency fallacy,” the tendency to infer the amount of energy required by an

appliance from its energy rating (Waechter et al., 2015a; Waechter et al., 2015b) rather than from the estimated kWh usage. For the same reason, consumers may end up buying appliances that are efficient but also consume more because they are bigger—which is the "volume-effect" (Stadelmann and Schubert, 2018). Furthermore, the estimated annual kWh usage is not easily translatable into economic terms. This would require the consumer to retrieve the price he or she pays for a kWh of electricity and compute the potential cumulative savings from running an appliance over the years relative to the initial price for each appliance he or she is considering buying. The non-availability of such information and the cognitive effort associated reduces the likelihood that energy savings will be considered preeminently in the purchase decision (Blasch et al., 2019). For these reasons, kWh per year is considered an opaque characteristic (DECC, 2014).

FIGURE 2.1 Causes of the energy-efficiency gap

Source: own elaboration based on the authors' literature review

A few recent field experiments manipulated appliance labels by explicitly including the economic cost of operating the appliance. The effects were, however, inconclusive: this intervention led to a modest increase in the purchase of energy-efficient tumble dryers and washer driers, but it was ineffective or in some cases, it even decreased the purchase of energy-efficient refrigerators in different experiments (Kallbekken et al., 2013; Department of Energy and Climate Change, 2014; Schubert and Stadelmann, 2015). More specifically, Kallbekken et al. (2013) deployed a redesigned efficiency label showing estimated lifetime operating costs for tumble dryers and fridges-freezers. They found no statistically significant effect for fridges-freezers and a 4.9% reduction in average energy use for tumble dryers (the energy savings were only 3.4% when the effect of staff training was excluded). The authors concluded that this type of intervention would be effective only for appliances for which the energy cost constitutes a major portion of the total lifetime cost. A field experiment by the UK Government's Department of Energy and the Behavioral Insights Team added a tag on top of the EU energy-efficiency label displaying estimated lifetime electricity costs for combined washer-dryers, washing machines and

dryers in 19 electronics stores across the country. They monitored sales in 19 other stores of the same chain that were exposed solely to the EU energy-efficiency label as the control group (Department of Energy and Climate Change, 2014). The experiment yielded a 0.7% reduction in the energy consumption of washer-dryers sold to the treatment group and no significant effect for the two other appliances. A cost–benefit analysis from a nationwide adoption of the intervention revealed that despite the limited impact of the treatment, the benefits from avoided CO2 emissions would vastly outweigh its low implementation costs. In 2015, an online experiment commissioned by the Swiss Federal Office of Energy conditioned the online purchases of freezers, vacuum cleaners, tumble dryers and televisions with two alternative energy labels. Buyers were either exposed to the standard EU energy label or to another displaying i) the lifetime operating costs expressed as losses or gains relative to the average of all appliances; and the ii) annual electricity cost from running the appliance, expressed as a color-coded scale comparing products of the same typology. Both labels led to higher purchases of energy-efficient appliances compared with the baseline scenario with no label. The energy-cost label was slightly more effective in reducing average energy consumption for tumble dryers compared with the EU energy label (by an additional 1.6 percentage points), but both had no effect on the purchase of freezers. The EU label was instead twice more effective than the energy-cost label in reducing energy consumption (−10.2% against −4.5%) from the purchase of efficient vacuum cleaners (Schubert and Stadelmann, 2015). In a hypothetical experiment, Skourtos et al. (2021) found that displaying the annual operating costs on energy labels of refrigerators did not affect choices, because the annual differences in operating costs were relatively low.

As these studies show, providing information on operating costs can, in some cases, lead to modest efficiency increases, particularly if operating costs are high relative to the total lifetime costs. But it can be ineffective or even counter-effective if the operating costs are quite low, such as for small appliances (e.g., vacuum cleaners) or if they are expressed in annual differences. These limited effects may be due to the fact that merely showing operating costs is not enough to influence individual temporal preferences. To this purpose, we manipulate the information on present and future costs by making the intertemporal dimension of choice more obvious to the prospective consumer. Our experiments recreate the status quo—where electricity consumption information is expressed in kWh, but we also reproduce the treatments of the experiments mentioned above—merely translating electricity consumption in economic terms—in order to use these results as benchmarks against which to evaluate our own treatments. This enables us to compare with previous experiments but also to investigate whether manipulating the information in a way that makes the intertemporal trade-off more explicit can increase the choice of energy-efficient appliances beyond merely expressing the energy consumed in monetary terms.

Behavioral studies aimed at depicting a realistic understanding of intertemporal choice have highlighted two opposing prevailing intertemporal preferences (Berns et al., 2007). On the one hand, they showed individual preferences for immediate gratification. On the other hand, a lesser-known strand in the literature has shown that individuals have a preference for improving outcomes, i.e., saving the best for later (Loewenstein and Prelec, 1991; Loewenstein and Sicherman, 1991; Chapman, 2000; Frederick et al., 2002). While the former strand of literature depicts individuals as shortsighted and present-biased, the latter proposes that they are patient and forward-looking. The implications for energy-saving investments are straightforward. The former approach suggests that they are unlikely to occur because individuals positively discount future energy and monetary savings, whereas the latter depicts a more optimistic view, suggesting that people can anticipate the future benefits of energy-saving investments and make sacrifices in the present with that perspective. While neoclassical economic theory postulates that individual time preferences are constant in eliciting the same choice options, regardless of the way they are framed (Tversky et al., 1988), a variety of framing effects have been found to affect intertemporal choice (Lewis, 2018). As Ebert and Prelec (2007) observed, the temporal dimension has an “optional status,” in that it can be pushed into the background or become a key concern depending on aspects of the choice situation. This makes sensitivity to time extremely susceptible to manipulations, such that simply drawing people's attention to time can eliminate present bias (Goodman et al., 2019; Lewis, 2018). The variability in reported discount rates between and within product categories,

mentioned at the beginning of this section, would seem to suggest that discount rates are indeed malleable and sensitive to framing (DEFRA, 2010).

In particular, our experiments are inspired by two well-documented framing effects, *hidden-zero framing* and *delay/speed-up asymmetry*. The *hidden-zero framing* explicitly expresses that in the future, the individual will be getting nothing or even losing from choosing immediate gratification. By unveiling the otherwise hidden opportunity costs of impatience, the effect of this framing was found to reverse temporal preferences and induce more forward-looking choices in several experiments (Loewenstein and Prelec, 1993; Read et al., 2005; Magen et al., 2008; Wu and He, 2012; Scholten et al., 2016; Read et al., 2017) and to reduce implicit discount rates (Faralla et al., 2017). In the *delay/speed-up asymmetry* framing, individuals are either asked to delay immediate gratification or to anticipate a later reward; evidence shows that people discount more under the first condition (Weber et al., 2007). This strand of research suggests that evoking forward-looking thoughts in the choice process (such as recalling the future electricity savings of a more efficient appliance) can lead to less impatient choices. Frederick and Loewenstein (2008, p. 233) concluded that individuals possess various cognitive patterns which "may be evoked or suppressed by subtle contextual features" and that pairing events in a sequence may encourage individuals to consider emotions they may have otherwise not included in the decision process. These studies suggest that simply changing the construal of alternatives without changing their actual value has an impact on our ability to make optimal intertemporal decisions (Magen et al., 2008).

To our knowledge, only three studies analyzed the relationship between pure temporal preferences and the energy-efficiency gap. In two hypothetical online experiments, Enzler (2013) and Schleich et al. (2019) found that individuals who were more present-oriented were less likely to choose energy-efficient options. In a similar setting, Newell and Siikamäki (2015) found that the US energy label that shows the estimated operating costs of running different electrical appliances is less effective on individuals who discount more future outcomes. These authors show that present-focused time preferences are associated with higher discounting of future energy savings, and that leads to underinvestment in energy efficiency. If time preference has a role in determining the adoption rate of energy-efficient appliances, and if it is not an innate and immutable individual characteristic but can instead be influenced (Chapman, 1998), then it should be possible to increase energy-efficient investments through framing manipulations.

2.3 Methods

We developed our hypothetical experiment in three stages. We first conducted a pilot of the experiment on undergraduate students at a Spanish University to understand how they approached and processed large purchases decisions and how to make the hypothetical choice more realistic and easier to relate to. The information collected was used to define the choice card design and refine the textual messages. Second, we tested the two core treatments on energy consumption information on another 224 undergraduate students, the results from this test are included as Annex 1. Third, we run the actual experiment on a nationally representative sample of the US population. The experiment was awarded funding and implemented through the Time-Sharing Experiments for the Social Sciences (TESS), a program financed by the US National Science Foundation (NSF).4 The sample used for the experiment consisted of 2010 adults (51.6% female, mean age = 48.3 years) from an AmeriSpeak pre-screened pool of participants who were invited to respond to a survey online between June and August, 2020.

Experimental design and additional data requirements

Participants chose between two refrigerators, an energy efficient one—here in the article referred to as green—and an otherwise identical, less efficient alternative—gray. We defined the context as a refrigerator replacement decision and the choice as being between two appliances that the participant

had hypothetically pre-selected among various models. Participants were told that the two refrigerators differed solely in price and energy consumed and that they were otherwise equal. The experiment followed a 2 × 3 factorial between-subjects design: one factor defining alternative framings of the appliances' energy requirements and the other factor pertained to the number of attributes shown for each refrigerator.

The energy consumption factor had three levels:

i. *Control:* cards showing the purchase price and the annual electricity usage in *kWh* of each appliance. This level reproduces the status quo.
ii. *Treatment 1 (T1):* cards showing the purchase price and the annual electricity cost for the expected lifetime of each appliance. This level reproduces what has been done in the earlier literature, in both field and hypothetical experiments. This enables us to compare our own treatment (T2) below, against previous findings.
iii. *Treatment 2 (T2):* cards showing the purchase price, the annual electricity cost for the expected lifetime of each appliance, and an additional "patience-inducing" message on each card showing the lifetime loss (avoided loss) in electricity cost compared with the more efficient (less efficient) appliance. The message mentions the date by which such loss (gain) would be realized, potentially engaging participants into anticipating their future emotions in that regard.

The second factor had two levels:

i. *High focus on electricity consumption: cards* showed only price and electricity consumption for each appliance, which reflects the standard practice of hypothetical choice experiments in this field.
ii. *Low focus on electricity consumption:* cards showed also additional appliance features such as total capacity, freezer capacity, color, and an image. These additional features varied marginally such that participants would be expected to be indifferent to them, and they were randomly assigned to either the energy-efficient or inefficient option. The purpose of adding these features was to mimic a more realistic choice environment where several appliance features are presented to the prospective buyers; and to test whether the effectiveness of our treatments would diminish when more information competed for the user's attention, which is similar to what was done in Andor et al. (2020).

Participants were randomly assigned to one of the resulting six groups. Table 2.1 summarizes the six conditions and illustrates the actual choice cards participants were presented with.

After the experimental session, all participants responded to the same post-experiment questionnaire, which included three sections:

i) a text asking for the percentage of electrical appliances out of the total they had bought in the previous three years that had the Energy Star certification[9];
ii) one question where they had to rate on a Likert scale of 0–5 how representative five statements were of them. These items were taken from the Consideration of Future Consequences Scale (Strathman et al., 1994), a scale which was used to measure individual temporal preferences and that was adopted in previous similar studies (Enzler, 2013); and
iii) a matrix where they had to rate how much they agreed on a Likert scale of 0–5 with a statement declaring that individuals can play an important role in protecting the environment. This question is the same used in the Eurobarometer survey and it is normally interpreted as a measure of ascription of personal responsibility to take care for the environment.

[9] Energy Star is a voluntary certification system in use in the United States. Electrical appliances need to have passed a series of efficiency tests established by the Environmental Protection Agency in order to bear the Energy Star yellow sticker.

TABLE 2.1 Matrix summarizing the 6 experimental conditions

<table>
<tr><td></td><td colspan="3">Factor 1: Electricity cost framing</td></tr>
<tr><td>Factor 2: Competing attributes</td><td>kWh: annual electricity usage in kWh</td><td>Electricity cost: the total electricity cost in US$ for the expected lifetime (20 years) of each appliance</td><td>Electricity cost loss: the total electricity cost in US$ for the expected lifetime (20 years) of each appliance. An additional message showing the lifetime loss (avoided loss) in electricity cost compared to the more efficient (less efficient) appliance.</td></tr>
<tr><td>Only purchase price and electricity consumption</td><td>Control: group 1
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>608 kWh/year</td><td>825 kWh/year</td></tr></table></td><td>Group 2
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>$1591/20 years</td><td>$2158/20 years</td></tr></table></td><td>Group 3
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>$1591/20 years
You avoid losing $567 in energy costs through 2040.</td><td>$2158/20 years
You lose $567 in energy costs through 2040.</td></tr></table></td></tr>
<tr><td>Purchase price and electricity consumption + Additional attributes</td><td>Group 4
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Image</td><td>  </td><td>  </td></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>608 kWh/year</td><td>825 kWh/year</td></tr><tr><td>Total capacity</td><td>24.6 Cubic Feet</td><td>24.4 Cubic Feet</td></tr><tr><td>Freezer capacity</td><td>8.9 Cubic Feet</td><td>8.9 Cubic Feet</td></tr><tr><td>Color finish</td><td>Stainless Steel</td><td>Metallic Steel</td></tr></table></td><td>Group 5
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Image</td><td>  </td><td>  </td></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>$1591/20 years</td><td>$2158/20 years</td></tr><tr><td>Total capacity</td><td>24.6 Cubic Feet</td><td>24.4 Cubic Feet</td></tr><tr><td>Freezer capacity</td><td>8.9 Cubic Feet</td><td>8.9 Cubic Feet</td></tr><tr><td>Color finish</td><td>Stainless Steel</td><td>Metallic Steel</td></tr></table></td><td>Group 6
<table><tr><th></th><th>Refrigerator A</th><th>Refrigerator B</th></tr><tr><td>Image</td><td>  </td><td>  </td></tr><tr><td>Price</td><td>$1373.99</td><td>$1099.99</td></tr><tr><td>Electricity consumed</td><td>$1591/20 years
You avoid losing $567 in energy costs through 2040.</td><td>$2158/20 years
You lose $567 in energy costs through 2040.</td></tr><tr><td>Total capacity</td><td>24.6 Cubic Feet</td><td>24.4 Cubic Feet</td></tr><tr><td>Freezer capacity</td><td>8.9 Cubic Feet</td><td>8.9 Cubic Feet</td></tr><tr><td>Color finish</td><td>Stainless Steel</td><td>Metallic Steel</td></tr></table></td></tr>
</table>

Several variables with socio-demographic data about participants, as well as their political views, saving habits, living conditions, and calculus abilities that had been gathered by the National Opinion Research Center (NORC) in previous surveys were made available to the researchers. The full survey and additional screenshots of the experiment are included as Annex 2.

Appliance choice

We chose refrigerators, among other electric appliances, for the following four reasons. First of all, refrigerators are among the most energy-consuming appliances in the household; therefore, operating costs over the lifespan of the appliance are quite significant. Second, refrigerators are running all the time, and therefore we can reliably estimate the energy they consume independent of usage patterns, unlike air conditioners or dryers, where household size or the local climate would hamper these estimations. Third, refrigerators are the most common energy-intensive appliances. Hence, this hypothetical experiment is directly relatable to a high number of participants. Fourth, previous research shows that individuals discount the future cost of operating refrigerators at a much higher rate than any other appliance (between 39 and 300%) (Train, 1985; DEFRA, 2010; Epper et al., 2011), thus indicating a high potential for behavioral intervention.

Appliance characteristics

In the literature, an energy-efficiency gap exists if there is an energy-efficient product that is cheaper in terms of total lifetime costs (adding capital and lifetime energy-running costs) than other less efficient equivalents, yet it is not purchased (OECD, 2017). Consistent with the literature (Newell and Siikamäki, 2015), to represent the trade-off between a higher purchasing price and lower energy consumption, one appliance has a lower purchase price but a higher energy cost, such that the difference in energy costs is higher than the difference in purchasing costs. More specifically, the capital cost of the inefficient appliance xa is lower than that of the efficient xb, but its yearly operating costs ya are higher than those of the efficient appliance yb. Hence, over the lifetime of the appliance, the operating cost savings from running the efficient appliance—discounted by the rate r, the opportunity cost of capital—outweigh the initial difference in their capital costs.

$$x_a < x_b \qquad y_a > y_b \qquad \delta^t > 1 \qquad \sum_{t=0}^{T}(y_a - y_b)\delta^t > (x_b - x_a) \quad (1)$$

where $\delta^t = 1/(1 + r)^t$ is a discount factor representing the value of one unit of currency, delayed by one year, given the rate faced by the consumer for borrowing and lending money. To ensure that each refrigerator option is realistic, we determined the range of operating costs and the range of purchase prices in a way that matches the actual range of appliances currently available in the US market. To determine the appliances' purchase prices, we selected a mid-sized refrigerator typical of the reference market6 and analyzed the appliances available within this capacity range in the online catalogues of the three chief appliance retailers at the time of the survey (Sears, Best Buy, and Lowe's). This helped determine an initial range of prices. Within these ranges of prices:

i. The price of the less efficient appliance was fixed at the maximum within the 1st quartile of prices observed in the market for that capacity range. That price was $1,099.99.
ii. The price of the more efficient appliance was calculated as 25% more expensive relative to the price of the other product. That price was $1,373.99.

This pricing methodology is similar to a study commissioned by the European Commission (IPSOS, 2014). The two prices obtained with this methodology appear to be good estimates as they fall slightly below and slightly above the national averages, respectively. More specifically, according to the US Bureau of Labor Statistics, the yearly expenditure on refrigerators per household was on average US$83 in 2018 (US Bureau of Labor Statistics, 2020). Multiplying this sum by the average lifespan of non-commercial refrigerators, leads to an average appliance price that is between the two prices estimated.

The *range of estimated energy consumed in* kWh corresponds to the range available on the US Energy Guide label for all similar models available in the market. To calculate *yearly operating costs*, we multiplied the extremes of this range for the most up-to-date national average price of electricity per kWh in the country at the time of the survey, taken from the US Energy Information administration website (US$0.13/kWh, March, 2020 figure) (US EIA, 2020). *Lifetime operating costs* in US$ were calculated by multiplying the yearly operating costs by the average years of duration. Lifetime operating costs were not discounted, because the intent of the exercise was to let individuals apply their own discount rate in full. We deemed imposing a discount rate and explaining the concept of discounting to laypersons to unnecessarily complicate and distort responses as results from focus groups in Kallbekken et al. (2013) also demonstrate. This choice is consistent with the literature (Kallbekken et al., 2013; DECC, 2014; Stadelmann and Schubert, 2018). After reviewing different estimates of the *average years of duration for residential refrigerators* in the US, we chose the estimate from the latest analysis available on the topic, undertaken by the E.O. Lawrence laboratory at the Berkley University (Lutz et al., 2011). Differently from earlier estimates which rely on informal manufacturers' experiences (US AIS, 2000), Lutz et al. (2011) combined residential survey data with manufacturer data on historical shipments. The authors conclude that the average lifespan of a refrigerator in the US is 19.7 years, which we rounded up to 20 years for simplicity in the experiment.

Hypothetical bias

It is possible that choices made in a hypothetical environment may differ from choices in the real world. For instance, individuals may be unable to accurately represent their preferences if given a hypothetical scenario they had never experienced. Alternatively, they may not engage enough with experimental choices when they are not going to bear any consequences in real life. Experimental economics typically addresses this limitation by adding real incentives to experiments, thereby linking real consequences to the hypothetical environment. Unfortunately, compensating participants with economic sums proportional to the amounts mentioned in our experiment was financially unfeasible with such a large number of participants.

However, there is no reason to believe that the hypothetical bias would have affected a specific treatment group more strongly. Rather, we think that if there was any hypothetical bias, it should have affected all groups equally. In this sense, we expect the relative differences in the outcome variables of the different groups to be potentially comparable with what they would be in a real world context. Likewise, studies comparing hypothetical choice settings with revealed preference approaches have shown that treatment effects tend to be of the same size (Carson et al., 1996; Ebeling and Lotz, 2015) or significantly correlated (Attanasi et al., 2018). Finally, to check for hypothetical bias, we analyze answers to the question regarding how many energy-efficient electrical appliances participants had purchased in the last five years. Comparing these answers with experimental choices allows us to detect potential hypothetical biases. An additional advantage of survey experiments, compared with a field experiment, is that they allow us to tightly control the decision environment, and they provide a vast array of information on our participants. This enables us to identify and disentangle various elements that concur with the end result and unveils the behavioral mechanisms defining individual choices.

Outcome variables and analysis

Differences between the choices of the treatment groups revealed the effectiveness of performing the two treatment manipulations against the baseline scenario in the promotion of energy-saving investments. The main outcome variable is the percentage of individuals choosing to purchase the energy-efficient (green) appliance over the less efficient (gray) one. Based on these percentages, we are able to calculate the estimated energy savings generated from each treatment, had such appliances been purchased in the real world.

To establish the determinants of energy-efficient choices, we estimate logit regressions of the form:

$$Y_{(i)} = \beta \cdot Treatment_{1(i)} + \gamma \cdot Treatment_{2(i)} + \delta \cdot FOS_{(i)} + \theta \cdot Treatment_{1(i)} \cdot FOS_{(i)} +$$

$$\vartheta \cdot Treatment_{2(i)} \cdot FOS_{(i)} + \mu Attr_{(i)} + a_{(i)} + \varepsilon_{(i)} \quad (2)$$

Where $Y_{(i)}$ is our dependent variable. It is a 0–1 dummy variable set to 1 participant *i* chose the green appliance, and 0 otherwise.

$FOS_{(i)}$ stands for Future Orientation Scale. It is a 5–25 scale measuring individuals' temporal orientation; the higher the value, the more future-oriented the individual is. Additionally, we look for interaction effects between the treatments' variables and $FOS_{(i)}$.[10]

$\mu Attr_{(i)}$ is a 0–1 dummy variable set to 1 if the participant could see additional appliance attributes in the choice cards, such as image and total capacity, and 0 otherwise.

$a_{(i)}$ is a vector consisting of individual-level and state-level socio-demographic controls as well as a control for individual environmental orientation. These controls increase the precision of our estimates and correct for the slight socio-demographic imbalances observed between groups. The controls included are:

i. Demographic controls: sex, age, race, education, employment status, marital status, State, religion, church attendance, ideology, party ideology, and financial literacy.
ii. Household characteristics controls: home type, household size, telephone service type, metropolitan area dummy, and internet availability.
iii. Economic indicators: household income scale, three dummy variables capturing whether the person expects their economy to worsen in a year, whether the person saves systematically a portion of income, and whether the person pays rent for his or her home.
iv. Environmental orientation: whether the person feels he or she can play a role in caring for the environment, on a 1–5 scale.

2.4 Results

In this section we include results organized by topic, combining results from our econometric analysis with qualitative analysis.

While random assignment of participants to groups presumably leads to homogenous groups, we calculated descriptive variables of the sample by group to ensure that these groups were balanced (Table 2.2). Groups were homogenous, as the *p*-values of the ANOVA test of equal variances (for the continuous variables) and the *p*-value of the Kruskal-Wallis test (for the ordinal variables) show.

Effect of treatment on appliance choice

We start with a graphical representation of our key results. The variable of interest across all groups is the percentage of participants picking the green appliance. As shown in Figure 2.2, the proportion of participants choosing the green appliance increases from 57% (in the control group) to 72% in T1 and to 75% in T2 when the survey displays only the appliance prices and electricity requirements.

The same upward trend from Control to T2 is repeated when additional appliance features are shown to the participants (from 47% to 71%). However, the percentage of green choices is always lower compared with the case in which these additional features are not shown. Introducing more appliance features clearly reduces the participants' focus on energy efficiency, leading to a greater proportion of energy-inefficient choices. Even in this context, which mimics more closely a real-life choice environment, T1

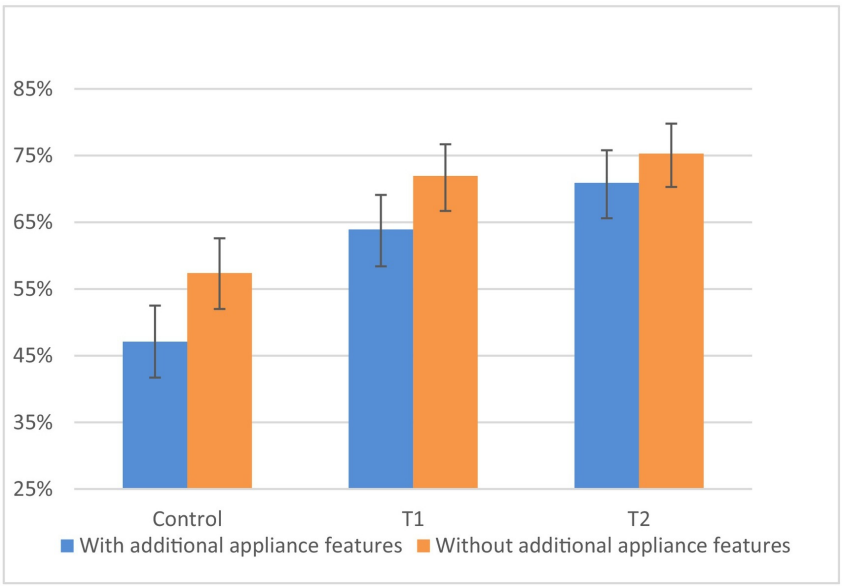
[10] FOS was constructed by summing answers on a 1–5 scale to 5 questions measuring individual future orientation.

and T2 appear to be particularly effective, with a 17- and 24-percentage point increase in green refrigerator choices, respectively, compared with the control group. A Kruskal-Wallis H test was conducted to determine if the likelihood of choosing the green appliance was different for the three conditions. The test showed that there is a significant association between treatment and appliance choice. There is a statistically significant difference in the likelihood of choosing the green appliance between the three groups ($\chi 2(5) = 57.756$, $p = 0.0001$).

TABLE 2.2 Main descriptive statistics of the sample by group

Variables	Control. with additional features (1)	Control (2)	T1. with additional features (3)	T1 (4)	T2. with additional features (5)	T2 (6)	p-value form F test (7)
Median age	46.95 (0.905)	48.74 (0.923)	47.91 (0.923)	47.60 (0.951)	49.76 (0.949)	49.05 (0.939)	0.294
Female (%)	51%	53%	54%	49%	50%	53%	0.8572
Income (1 v. low–18 v.high)	9.75 (0.229)	9.75 (0.214)	9.71 (0.230)	10.26 (0.211)	10.10 (0.248)	10.16 (0.220)	0.322
Education	9.57 (0.150)	9.55 (0.153)	9.42 (0.159)	9.62 (0.166)	9.61 (0.173)	9.45 (0.169)	0.934
Future Orientation Score (FOS)	17.87 (0.198)	17.78 (0.198)	17.77 (0.205)	18.15 (0.196)	18.29 (0.183)	18.24 (0.179)	0.192
Individual Responsible for the environment (1 agree–5 disagree)	4.29 (0.278)	4.35 (0.271)	4.37 (0.292)	4.40 (0.291)	4.32 (0.296)	4.10 (0.052)	0.973
In the next years my income will worsen (%)	56%	56%	57%	58%	53%	58%	0.888
Energy Star purchases (%)	39.63% (2.53)	35.86% (2.42)	38.75% (2.52)	40.32% (2.56)	34.68% (2.47)	38.11% (2.49)	0.575
N. participants	**344**	**352**	**327**	**328**	**323**	**336**	

FIGURE 2.2. Proportion of energy-efficient choices per condition



Source: own computations based on own experimental data on 2,010 US adults. Error bars show confidence intervals at 95% level.

We calculated the total kWh/year that would be consumed under the Control and T2 scenarios (with additional appliance features) by taking into account the percentage of individuals choosing green appliances in those conditions, and we found that total kWh consumption decreases by 7.15%. Considering that 12.4 million refrigerators were sold in the US in 2019 (AHAM, 2020), we calculated the potential energy savings that could be generated on a national scale, assuming that choice was restricted to these two models. We estimated energy savings worth 642.6 million kWh/per year for the refrigerators sold in a given year. Hypothetical experiments are believed to be better suited to provide qualitative rather than quantitative insights (Epper et al., 2011). In order to establish a comparison between our hypothetical experiment and the field experiments mentioned in the literature section, we compared the decrease in kWh consumption they achieved with our T1—which reproduces the treatments provided by these experiments in a hypothetical scenario—. The decrease in kWh achieved in our T1 totals 5% (when additional appliance attributes are included) or 4.5% (when choice-cards only mention price and electricity cost). In the field experiments testing the same treatment as in T1, the decrease in kWh obtained ranged between 0 and 4.9%, depending on the experiment and the appliances being considered. So, while we cannot reliably predict the size of the effect that T2 would have in a field or real world scenario, we can nonetheless observe that the effect of our T1 falls withing the range observed in field experiments. As such, we could expect that T2 could produce effects that are commensurate in size to our experimental results.

The results of our econometric estimations are reported in Table 2.3. In column 4, we find that both T1, i.e., merely expressing energy cost in total € over 20 years of use, and T2, i.e., adding a message highlighting the relative future losses compared with the other appliance, are both statistically significant at the 99% confidence level (controlling for demographic and household characteristics). The coefficients show that being in either group increases the likelihood of choosing the green appliance, compared with the control group. These results are robust regardless of whether socio-demographic controls and household characteristic controls are included (columns 2–4). In column 8, we compute marginal effects based on the equation in column 7, and we find that being in T1 increases the probability of choosing the green appliance by 16.6%, while being in T2, increases the likelihood of choosing the green appliance by 19.7%. Both estimates are statistically significant at the 99% confidence level. Pseudo-R2 reaches 10%. This level of R2 is similar to that of other papers in the field and is considered an acceptable level, given the complexity of human behavior (Langbein, 2015). Based on the qualitative and quantitative evidence presented, we are able to conclude that T2 is statistically more effective than T1 in increasing energy-efficient choices.

Participants who visualized additional information on the refrigerators—beyond price and electricity requirements—were less likely to choose the efficient appliance. We thus interpret this result as the consequence of a distraction from electricity consumption information. The additional refrigerator characteristics (image, total refrigerator capacity, and color) varied minimally between appliances and were randomly associated with either the green or gray appliance. We thus expected that participants would be indifferent to these differences. To check for this hypothesis, in column 5, we include dummy variables capturing whether individuals chose refrigerators with Image A, stainless steel color, a marginally smaller total capacity, and smaller refrigerator capacity. We find that only the coefficient for smaller freezer size is statistically significant and has a negative sign, signaling that a preference for a slightly larger freezer explains a small part of the above result. Yet, we notice that adding these controls to the regression does not alter the findings previously discussed; the other coefficients maintain their sign and size. Electricity prices in the US, vary widely across States. At the time of the survey they ranged between US$0.09/kWh in Oklahoma to US$0.32/kWh in Hawaii. We thus added State level kWh electricity price as an independent variable in our model but did not find a statistically significant effect, and we thus did not report this regression. It is to be expected, however, that the effect of T1 and T2 would be even more pronounced in countries with higher electricity prices, should operating costs be calculated using local prices as opposed to the national average, an expectation which is line with findings from Davis and Metcalf (2016).

TABLE 2.3 Regression output

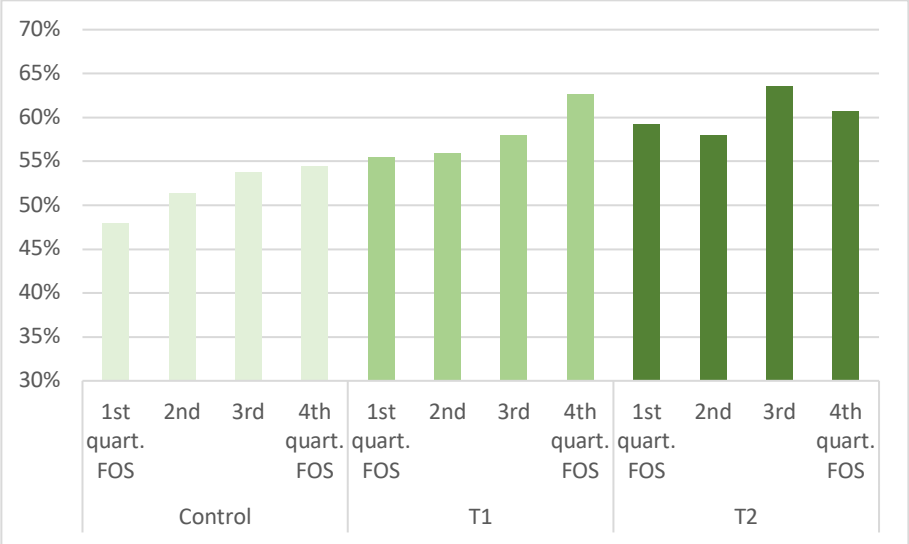
	Appliance choice (Logit)										
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)** dur>4 min.	**(8)** Marg.eff.	**(9)** dur>9 min.	**(10)**	**(11)**
Treatment 1: operating costs info	0.647*** (0.148)	0.649*** (0.147)	0.671*** (0.151)	0.701*** (0.151)	0.710*** (0.150)	0.713*** (0.150)	0.835*** (0.177)	0.166*** (0.032)	0.192 (0.365)	0.106 (0.694)	0.702*** (0.151)
Treatment 2: operating costs info+ patience-inducing message	0.877*** (0.151)	0.882*** (0.152)	0.877*** (0.155)	0.904*** (0.155)	0.885*** (0.155)	0.926*** (0.155)	0.997*** (0.180)	0.197*** (0.032)	0.729*** (0.047)	0.906*** (0.154)	1.213 (0.771)
FOS	0.053*** (0.018)	0.051*** (0.018)	0.059*** (0.019)	0.057*** (0.019)	0.058*** (0.019)	0.056*** (0.019)	0.053*** (0.021)	0.011*** (0.004)	0.146*** (0.047)	0.046** (0.023)	0.062** (0.022)
-FOS*T1										0.033 (0.038)	
-FOS*T2											-0.017 (0.041)
Additional Appliance Attributes		-0.455*** (0.124)	-0.467*** (0.128)	-0.477*** (0.128)		-0.478*** (0.128)	-0.313*** (0.145)	-0.066** (0.030)	-0.821*** (0.335)	-0.475*** (0.128)	-0.475*** (0.128)
-Image A dummy					0.005 (0.167)						
-Stainless steel dummy					-0.250[a] (0.159)						
-Smaller freezer					-0.329** (0.162)						
-Smaller total capacity					0.181 (0.167)						
Pessimist beliefs about future income (dummy)						0.090 (0.132)	0.101 (0.152)	0.021 (0.032)	0.436 (0.312)		
NoSave (dummy)						-0.259* (0.160)	-0.198 (0.184)	-0.043 (0.040)	-0.207 (0.364)		
Income						0.007 (0.020)	0.004 (0.023)	0.001 (0.004)	0.003 (0.045)		
Rent (dummy)						0.002 (0.204)	0.008 (0.211)	0.001 (0.044)	-0.282 (0.438)		
Republican Party (dummy)						-0.368** (0.175)	-0.493*** (0.200)	-0.107*** (0.044)	-0.135*** (0.444)		
Environmental Values						-0.004 (0.009)	0.177** (0.075)	0.037** (0.015)	0.059** (0.024)		
Financial literacy (dummy)						-0.193 (0.181)	-0.226 (0.204)	-0.048 (0.204)	-0.390 (0.395)		
Demographic controls	N	N	Y	Y	Y	Y	Y		Y	Y	Y
Households characteristics controls	N	N	N	Y	Y	Y	Y		Y	Y	Y
Observations	2010	2010	2006	2006	2006	2006	1576		476	2006	2006
Pseudo R-squared	0.032	0.041	0.094	0.100	0.102	0.105	0.140		0.290	0.102	0.099
P-value F test	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000

Notes. [a] P-value F test nearly statistically significant at 0.111.
* Significant at <.10, ** significant at <.05, *** significant at <.01. Standard errors in parentheses.
Demographic controls include sex, age, race, education, employment status, marital status, State, religion, church attendance, ideology). Households characteristics controls include home type, household size, telephone service type, metropolitan area dummy, and has internet dummy.

Effect of temporal orientation on appliance choice

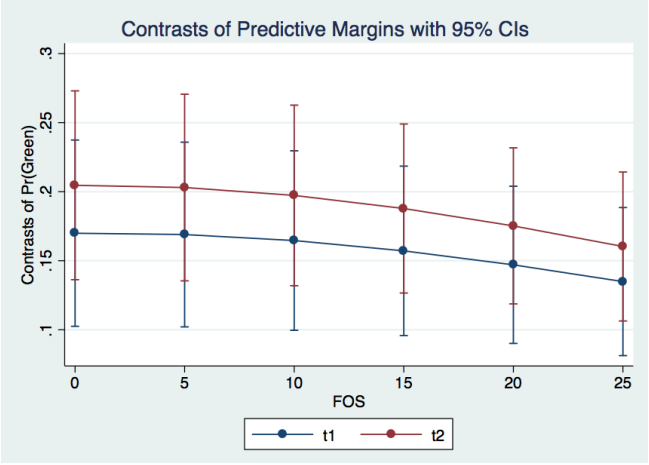
The temporal preferences survey allowed us to construct a continuous scale FOS, with higher values indicating that participants are more future-oriented. Fig. 2.3 below shows the proportion of energy efficient choices made by individuals clustered by their FOS quartiles. Data show that higher FOS scores (more patient individuals) are associated with a greater proportion of energy efficient choices. This pattern is, however, more obvious for individuals in the control group and in T1. From Fig. 2.3, we can also conclude that T2 is the most effective treatment for the most present-biased and the most forward-looking individuals alike (Q1–Q3). However, for individuals in the top quartile, T1 is slightly more effective than T2 when the additional appliance features are not present. Econometric analysis in Table 2.3 further confirms that more future-oriented individuals are more likely to choose the efficient appliance for every additional point in the FOS scale, the coefficients are statistically significant with positive sign at 0.01 significance level.

FIGURE 2.3 Proportion of energy-efficient choices by FOS quartile, per condition



Source: own computations based on experimental data

FIGURE 2.4. Marginal effect of being included in T1 and T2 on the likelihood of choosing the energy-efficient appliance (compared to the Control group), by FOS score.



Source: own computations based on experimental data. Predictive margins with 95% confidence levels.

Wondering whether the effect of individual temporal preferences depended on condition, we calculated the marginal effects of being included in T1 or T2 for each additional unit increase in the FOS score (Figure 2.4, calculated in the equation in column 7, Table 2.3). The effect of being included in T1 and T2 positively contributes to the likelihood of choosing the efficient appliance (compared to the Control

group). T2 is more effective than T1 for each FOS score level. The effect of both treatments is stronger on individuals with lower FOS scores and it diminishes as FOS increases. This finding matches the intuition that individuals who are already future-focused do not need as many reminders of the future consequences of choosing immediate gratification.

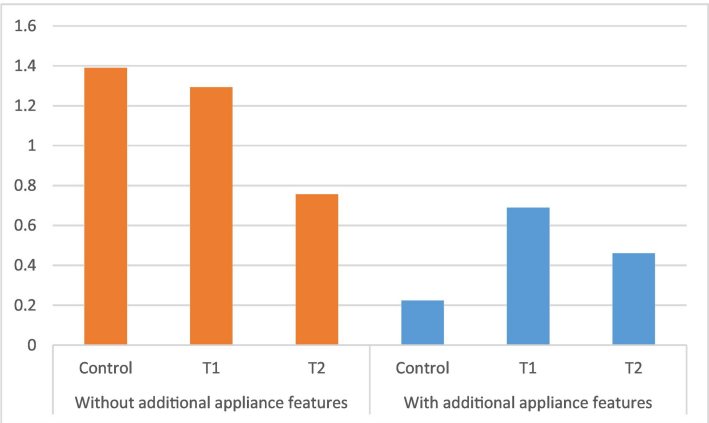
Additionally, we conducted a one-way ANOVA analysis to stablish whether there is a statistically significant difference in the FOS score between individuals who choose the green appliance and the gray appliance in each treatment group. Table 2.4 shows average values (for treatments excluding additional appliance features) and standard errors in parentheses. In all groups, individuals choosing the green appliance have higher FOS scores on average. However, the FOS score differentials are significantly narrower in T2, 46% and 42% less compared with the differences in the Control and T1 groups, respectively. These differences are statistically significant at the 0.01 and 0.1 significance level, as the p-values from F-tests in the last column indicate. This is also consistent with results from the Spanish pilot. We consider the narrow gap in FOS scores for T2 as an indication that reminding individuals about the future implications of the available choices with a priming message manages to partly control for pre-existing individual temporal preferences, possibly by convincing some impatient individuals to choose the efficient, more expensive refrigerator.

TABLE 2.4 Average Future Orientation Scores FOS per condition and choice (without additional features)

	Participants choosing gray	Participants choosing green	Difference	Average FOS per condition	F test and its p-value
Control	16.98 (0.331)	18.37 (0.248)	1.39	17.78 (0.203)	11.71 0.000
Treatment 1	17.23 (0.338)	18.52 (0.235)	1.29	18.16 (0.196)	8.95 0.003
Treatment 2	17.67 (0.380)	18.43 (0.202)	0.75	18.24 (0.179)	3.33 0.068
Totals	17.23 (0.205)	18.44 (0.131)	1.21	18.05 (0.112)	25.62 0.000

This effect, however, is not confirmed when additional appliance attributes are displayed, as Figure 2.5 below graphically illustrates. This suggests that the presence of a wider array of appliance features may water down the effects of T1 and T2 on temporal orientation. We also estimated interaction terms between FOS and T1 and T2. In both cases, however, the coefficients were not statistically significant (Table 2.3, columns 10 and 11).

FIGURE 2.5 Difference in average FOS between grey/green choices, by condition



Source: own computations based on experimental data

Effect of treatment on other individual characteristics

In column 6 of Table 2.3, we include the four economic controls and the environmental-orientation control previously mentioned, plus two dummies equal to 1 if the participant identifies to some extent with the Republican Party and if he or she could solve a basic percentage calculus. Of these additional variables, only identifying with the Republican Party has a statistically significant coefficient, with negative sign. This might be due to the well-documented climate-change skepticism of conservatives and a possible politicized perception of energy savings as a Democratic Party trait. This interpretation is consistent with Gromet et al. (2013) who found that politically conservative individuals are less in favor of energy-efficient investments.

We estimated a minimal response time for understanding the whole survey as requiring about 4 min. We thus repeat the regression in column 6 to exclude participants who completed the survey in less than 4 and 9 min, respectively (columns 7 and 9). If we restrict the analysis to answers that took more than 4 min, the coefficient for environmental orientation is statistically significant at the 0.05 significance level and has a positive sign. The R2 also increases, and the model contributes to explaining 14% or 29% of the observed variations in the response variable in columns 7 and 9, respectively.

We further investigate whether being in a particular treatment group affects the relevance of other variables. This can help explain the underlying mechanisms that lead one treatment to be more successful in promoting energy efficiency, compared with others. We thus rerun the regression in (6), splitting the sample by treatment condition. We first run the regressions split by the three conditions, Control, T1, and T2, without the additional appliance attributes (Table 2.5, columns 12–14). We start by noting that R2 rises from 10.5% (6) up to 40% with split regressions (14). This indicates that there are significant changes in the variables affecting choice in each treatment group. Indeed, FOS is the only variable that is statistically significant, with positive signs across all conditions while a series of coefficients changes sign or loses/gains statistical significance.

TABLE 2.5 Split Regression output

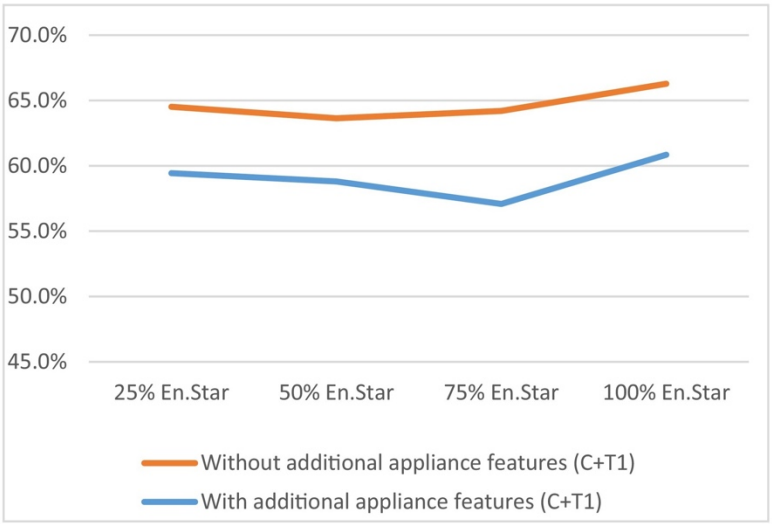
Variables	Appliance choice (Logit)					
	(12)	(13)	(14)	(15)	(16)	(17)
	Contr, no attr.	T1, no attr.	T2, no attr.	Control	T1	T2
FOS	0.183***	0.128***	0.195**	0.055*	0.101***	0.137***
	(0.052)	(0.057)	(0.101)	(0.034)	(0.035)	(0.042)
Additional Appliance Attributes				-0.545***	-0.680***	-0.344
				(0.216)	(0.247)	(0.263)
Pessimist beliefs about future income (dummy)	-0.649*	-0.425	1.048*			
	(0.391)	(0.489)	(0.562)			
NoSave (dummy)	-0.096	-1.312*	1.172*			
	(0.475)	(0.526)	(0.648)			
Income	-0.078	0.133*	0.148*			
	(0.067)	(0.077)	(0.086)			
Rent (dummy)	-0.850*	0.036	2.313***			
	(0.459)	(0.622)	(0.771)			
Republican Party (dummy)	-1.326***	-1.616***	-0.324			
	(0.535)	(0.622)	(0.691)			
Environmental Values	0.050	0.295	0.650**			
	(0.123)	(0.264)	(0.288)			
Financial literacy (dummy)	-0.128	0.904	1.044			
	(0.520)	(0.622)	(0.817)			
Demographic controls	Y	Y	Y	Y	Y	Y
Households characteristics controls	N	N	N	Y	Y	Y
Observations	329	286	272	679	634	618
Pseudo R-squared	0.312	0.338	0.400	0.165	0.214	0.180
P-value F test	0.000	0.000	0.000	0.000	0.009	missing

Notes.
* Significant at <.10, ** significant at <.05, *** significant at <.01. Standard errors in parentheses. Demographic controls include sex, age, race, education, employment status, marital status, State, religion, church attendance, ideology). Households characteristics controls include home type, household size, telephone service type, metropolitan area dummy, and has internet dummy.

The relevance of the economic variables varies widely in the three treatments. Having negative expectations about future income decreases the chances of choosing green in the control group (statistically significant coefficient with a negative sign); but it is not statistically significant in T1, and it increases the likelihood of green choices in T2 (statistically significant coefficient with a positive sign). We observe the same pattern for individual who live in a rented home (*Rent*). Likewise, people who do not save systematically are less likely to buy the green appliance in T1 but are more likely to buy it in T2. Higher income levels are associated with more green choices in T1 and T2 (statistically significant coefficient with a positive sign) but not in the control group. It thus appears that the loss-framed message in T2 nudges individuals who are worried about their income or who are usually unable to save towards the concrete possibility of saving in the future through an energy-efficient appliance. Some of these coefficients are, however, significant only at the 0.1 significance level confidence level, probably due to the smaller sample size for these split regressions.

Identification with the Republican Party negatively affects green choices in the control group and in T1 only. It is possible that the loss-framed message in T2 might dilute the perception of energy efficiency as a political matter by reframing it more strongly as a purely economic matter. Ascription of personal responsibility to care for the environment is statistically significant only in T2. Perhaps, mentioning a date in the future in T2, induced individuals who held pro-environmental attitudes to anticipate also the non-financial consequences of choosing the gray appliance. We hypothesize that this may have contributed to activate the effect of pro-environmental orientation in the decision process. When we run regressions by Control, T1, and T2 conditions without distinguishing whether the participants visualized additional attributes (columns 15–17), we find that in T2, the coefficient for Additional Attributes is not statistically significant. The result suggests that the loss-oriented message in T2 helps to contrast the cognitive noise introduced by the additional appliance features.

FIGURE 2.6 Proportion of energy-efficient choices and Energy Star purchases, by condition



Source: own computations based on experimental data

As an external validity test, we checked whether hypothetical choices made in the experiment were associated with participants' real-life choices by asking them to report the percentage of Energy Star-rated appliances they had bought out of their total relevant purchases in the previous three years. Figure 2.6 shows that the proportion of participants choosing the green appliance[11] slightly increases with the

[11] This graph includes only choices made in the Control group and in T1, since they represent more closely the status quo in US retailer shops, and they are thus the experimental conditions that are most comparable to the conditions US residents encounter when buying appliances. While electricity requirement information in shops is usually presented in *kWh* (mirroring the control group), all electrical appliances also come with a mandatory Energy Label that shows the estimated cost of operating the appliance for a year in US$ (somewhat similar to T1).

percentage of Energy Star appliances they had previously bought. For example, 64% of the people who purchased less than 25% of Energy Star products chose the green appliance in the experiment compared with 66% of those who bought only Energy Star appliances (for treatments excluding additional appliance features). Results from a Kruskal-Wallis H test, however, showed that the association between how many Energy Star rated appliances had been purchased in the past and appliance choice was not statistically significant. Nonetheless, we cannot rule out that the hypothetical decisions that subjects made in our hypothetical scenario are related to some extent to their real-life behavior in similar decision domains.

2.5 Discussion

These experiments analyzed the role of pure time preferences in the decision to invest in energy efficiency. They tested whether individuals could be nudged to be more patient and make more energy-efficient choices, which typically deliver higher environmental and economic benefits in the long run.

A nationally representative sample of 2,010 US adults faced a hypothetical purchase choice consisting of two refrigerators that differed solely in capital price and electricity consumed. The more efficient refrigerator was more expensive to purchase but cheaper to operate compared with the inefficient alternative. However, the overall total lifetime cost was cheaper for the efficient appliance. The treatments consisted of alternative framings of the appliances' energy requirements, showing the information expressed in either i) *kWh*/year (Control); ii) total electricity cost in US$/€ for the product's lifetime (T1); or iii) adding to lifetime cost a loss-framed message about the relative loss (or savings) of each appliance at a given date in the future (T2).

The literature on *hidden-zero framing* and *delay/speed-up asymmetry* states that individuals' temporal preferences can be influenced by contextual features that highlight the hidden opportunity costs in the choice situation or by evoking forward-looking thoughts. These features can potentially inspire alternative cognitive patterns that can improve individuals' ability to optimize their intertemporal decision making. Our core treatment T2 leverages these findings by highlighting the long-term economic losses with a message.

Previous experiments that displayed only electrical appliances' yearly or lifetime operating costs found either limited increases or even decreases in energy-efficient purchases. This might be due to the fact that energy-inefficient choices are in part driven by temporal preferences rather than by an information deficit. For example, Newell and Siikamäki (2015) found that displaying yearly operating costs has less effect on present-biased individuals.

While T1 reproduced the treatment from previous field experiments in the literature, T2 goes beyond the simple provision of energy-efficiency information, as it nudges individuals by making the hidden temporal component of the choice context a key concern in the decision process. T2 reaches the highest proportion of individuals choosing efficient appliances. The incremental effect compared with T1 is 7 percentage points. This results were in line with results from the Spanish pilot (in Annex 1), where T2 outperformed T1 by 6 percentage points. The fact that T2 outperforms T1 in both experiments, despite the use of two very different samples, suggests that nudging temporal preferences rather than merely informing about energy-cost implications works better for increasing energy-efficient choices. It also signals that there are concrete opportunities to increase energy-efficient purchases with simple and cost-effective framing interventions. Our treatment simultaneously lightens the cognitive load faced by perspective buyers—by computing the relative long-term convenience of the efficient appliance—; it leverages loss aversion, it promotes identification with one's future self—by mentioning a date several years into the future—. While the experimental design does not allow us to disentangle the single

Participants who did not buy any appliance in the previous three years, who replied with an absolute number rather than a percentage, or who skipped the question were excluded from the count, thus reducing the count to just 606 observations.

contribution of each of these components to the increase in energy-efficient choices, we do observe that our treatment affects the extent to which present-focused preferences are activated in the decision process.

We separately assessed individual temporal preferences using research-validated scales that employ a series of qualitative questions to construct an index identifying individuals on a spectrum between present-oriented and forward-looking. We used elements of the Zimbardo Future Orientation Score for the Spanish sample and the Consideration of Future Consequences Scale for the US sample. Qualitative and econometric analysis showed that in both samples, individual temporal preferences influence energy-efficiency choices. Present-oriented individuals were less likely to choose efficient appliances, whereas people who chose energy-efficient appliances had higher FOS scores. However, this difference did not equally apply to all treatment groups. The difference in FOS between those who chose the green and those who chose the gray appliance was nearly half in T2, compared with the control group. This finding was consistent in both the Spanish and the US sample. In addition, in the Spanish sample, econometric outputs showed that temporal orientation affected refrigerator choice only in the Control group, although this result was not replicated in the US sample. We interpret these findings as an indication that the treatments, T2 and partly T1, reduced the influence of pre-existing temporal preferences on energy-efficient choices. T2 was the most effective treatment for both the bottom and the top FOS quartiles of the US sample when several appliance attributes were shown. These results would seem to suggest that there is relationship between temporal orientation and energy-efficiency decisions. Pre-existing individual temporal preferences affect the likelihood that the individual will buy efficient appliances. However, this paper reinforces the idea in the literature that individual temporal preferences can be activated or pushed to the background by the choice architecture in place.

Hypothetical experiments in energy efficiency typically elicit preferences by showing only price and electricity requirements. This may raise the question of whether individuals can focus on energy efficiency as much in a real-choice environment where appliances are described with a wide array of features (appliances are described with a range of 40–70 features on US retailer websites and 10–30 on Spanish retailer websites). To increase the resemblance of our experiment to a real-choice setting, in the US experiment, we repeated the experiment by adding additional appliance features, such as color, total capacity, freezer capacity, and images. These features were randomly assigned and varied marginally between appliances, such that the participant should have been indifferent to them. However, we found that individuals in these latter treatments were less likely to choose the energy-efficient appliance. Nonetheless, we noted that T2 was still the treatment with a higher proportion of energy-efficient choices. Displaying additional appliance features diminishes the individual's attention to energy efficiency, but T2 succeeded in giving visibility to the consequences of choosing inefficient appliances. This finding is particularly relevant for policy: Giving prominence to the opportunity costs of appliance energy requirements might counter the distraction represented by multiple appliance features. However, the extent of this distraction may be higher in markets where a high number of appliance attributes are shown, such as the US market.

Economic indicators clearly influenced choice: household wealth, the availability of savings and difficulty paying bills were determining factors in appliance choice. This was somewhat predictable, since individuals need the financial means to pay the price premium that comes with energy efficiency[12]. However, qualitative analysis of people's explanations for their refrigerator choices in the Spanish pilot revealed two opposing attitudes towards economic constraints and appliance choice. Some participants felt that since they feared their future income might worsen, it would be best to save money immediately by buying the cheaper appliance. Other participants felt that saving in the long term through lower electricity bills would help them cope with a possibly lower income in the future. We thus investigated, whether the effect of individual economic situation on appliance choice was mediated by the treatments participants had been subjected to.

[12] In addition, also renting one own's living quarters impacted choice, which is also to be expected considering that homeowners may expect to spend more time in their homes and hence exploit their appliances for a longer time.

Split regression analysis in the Spanish and US sample showed that people that had no savings, who were economically worse-off, who lived in a rented home or who expected their income to decrease in the future were less likely to choose the green appliance if they had participated in the control group or T1. While participants in T2 with the same characteristics were more likely to choose the green appliance compared to the others. In the Spanish sample, the interaction term between economic pessimism and T2 was close to statistical significance ($p = 0.111$) and had a positive sign.[13] This result suggests that in the status quo, where electricity requirements are expressed in *kWh*, people worried about their future income may be tempted to follow a saving-now strategy and choose the cheaper, less energy-efficient appliance. In contrast, participants in T2 received a loss-framed message which reframed the more expensive, efficient appliance as an opportunity to lower their future electricity expenses and to better cope with a lower income in the future.

In the US sample, we extended the analysis to political identities and found that identifying to some extent with the Republican Party was negatively associated with the likelihood of choosing the efficient appliance, even when controlling for income and future orientation. However, this relationship was not statistically significant when the analysis was restricted to individuals in T2 and individuals who had been subjected to treatments displaying additional appliance features. Climate change is currently a highly politicized topic in the US, and it is possible that energy saving is seen as a Democratic Party interest, which would explain the Republican Party subsample's reluctance to choose the efficient appliance. However, we interpret our result as an indication that when the energy-efficiency information is framed in terms of personal economic losses (T2) or when energy efficiency information is dispersed among other appliance features (color, size, etc.), political views are not activated in the decision process. It suggests that labeling energy efficiency as climate-friendly may cause counterproductive reactions from individuals identifying with the Republican Party, and it highlights the potential for future research. This view is supported by Gromet et al. (2013), who found that conservatives were less likely to buy energy-efficient lightbulbs if they were labelled with environmental messages. Overall, findings in the two experiments were consistent with each other despite obvious differences in the sample demographic and socio-cultural characteristics, different electricity prices and appliance markets.

2.6 Conclusions

The experiments conducted in this paper prove that there is a strong correlation between individual pure time preferences and the likelihood they will invest in energy efficiency. Results suggest that pure temporal preferences play a role in explaining the energy-efficiency gap, and they can help to clarify why field experiments that provided information on the running costs of different appliances have not been as effective as had been hoped for in closing the energy-efficiency gap.

While the literature has traditionally considered temporal preferences as given and constant across domains, more recent experimental evidence suggests that intertemporal choice is sensitive to subtle variations in the choice architecture (Frederick and Loewenstein, 2008). More specifically, within the same individual, there coexist contrasting sets of preferences and cognitive patterns that are activated by specific cues. Pairing two events as part of a sequence (such as the time of purchase and future electricity payments) invites individuals to evoke emotions they may otherwise not have experienced and may induce them to make more forward looking choices by shifting their psychological perspective forward (Loewenstein and Prelec, 1991).

Findings in this paper corroborate the idea that temporal preferences can be activated or attenuated within a given choice context and that framing techniques can be leveraged to induce intertemporal choices that are both economically optimal in the long term for the individual and for the climate. In this paper, simply highlighting the long-term hidden costs of choosing an energy-inefficient appliance

[13] Results from the Spanish pilot are included as part of Annex 1.

by a given date into the future with loss-framed language increased energy-efficient choices up to 24 percentage points when compared with the baseline scenario and by 7 percentage points when compared with just displaying lifetime operating costs, as done in the previous literature. We hypothesize that the effectiveness of the treatment is delivered through two mechanisms: It lowers impatient choices by lowering the effect of impatient individuals' default temporal preferences, but it also redirects the attention of income constrained individuals towards energy-efficiency as a money saving strategy. For the US market, part of the effectiveness of the treatment was also due to the fact that mentioning the economic convenience of energy-efficient products neutralized the negative effect of conservative political views of climate-friendly initiatives.

The main policy implication of this paper is the suggestion to introduce temporally oriented nudges to increase energy-efficiency uptake and foster other pro-environmental behaviors. Our nudge can support economically constrained individuals to make choices that will help them to save money in the long term.

Random assignment in the experimental setup ensures there is a causal relationship between our treatments and the percentage of energy-efficient appliances chosen. The findings were consistent across two very different population samples and different appliance markets. This suggests that this simple and cost-effective nudge may be applicable to different socio-cultural contexts. The main limitation in our experiment concerns the lack of variation in the refrigerators' price and operating costs and the limited variation of the other attributes. While our choice was dictated by parsimony—i.e. the need to contain the total number of permutations within a given sample size—we recognize that varying the price and the operating costs would have enabled us to define marginal effects and to assess the effectiveness of our treatment on a wider range of appliances. Another limitation to our research is the lack of real incentives for participants. Future research could address both limitations by replicating this experiment in a field setting, it would validate our findings and effect sizes while extending the number and the levels of appliance attributes considered. Our nudge was designed for application in an online environment. As an extension of this paper, one could test its introduction at different steps in the purchase process to identify the moment that makes it most effective. Additional future research avenues in relation to this paper include the application of a similarly inspired nudge towards other pro-environmental behaviors by highlighting their opportunity costs.

2.7 References

Allcott, H. (2011). Consumers' perceptions and misperceptions of energy costs. American Economic Review, 101(3), 98–104. https://doi.org/10.1257/aer.101.3.98

Allcott, H., & Taubinsky, D. (2015). Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market. American Economic Review, 105(8), 2501–2538. https://doi.org/10.1257/aer.20131564

Allcott, H., & Wozny, N. (2014). Gasoline prices, fuel economy, and the energy paradox. *Review of Economics and Statistics*, *96*(5), 779–795. https://doi.org/10.1162/REST_a_00419

Andor, M. A., Gerster, A., & Sommer, S. (2020). Consumer inattention, heuristic thinking and the role of energy labels. *Energy Journal* (Vol. 41). https://doi.org/10.5547/01956574.41.1.mand

Association of Home Appliance Manufacturers (AHAM). (2020). Total unit shipments of refrigerators in the US. Retrieved July 8, 2020, from https://www.statista.com/statistics/220111/unit-shipments-of-refrigerators-and-freezers-in-the-us/

Attanasi, G., Georgantzís, N., Rotondi, V., & Vigani, D. (2018). Lottery- and survey-based risk attitudes linked through a multichoice elicitation task. *Theory and Decision*, *84*(3), 341–372. https://doi.org/10.1007/s11238-017-9613-0

Attari, S. Z., DeKay, M. L., Davidson, C. I., & Bruine de Bruin, W. (2010). Public perceptions of energy consumption and savings. *Proceedings of the National Academy of Sciences*, *107*(37), 16054–16059. https://doi.org/10.1073/pnas.1001509107

Berns, G. S., Laibson, D., & Loewenstein, G. F. (2007). Intertemporal choice – toward an integrative framework. *Trends in Cognitive Sciences*, *11*(11), 482–488. https://doi.org/10.1016/j.tics.2007.08.011

Blasch, J., Filippini, M., & Kumar, N. (2019). Boundedly rational consumers, energy and investment literacy, and the display of information on household appliances. Resource and Energy Economics, 56, 39-58. https://doi.org/10.1016/j.reseneeco.2017.06.001

Carson, R. T., Flores, N. E., Martin, K. M., & Wright, J. L. (1996). Contingent valuation and revealed preference methodologies: Comparing the estimates for quasi-public goods. *Land Economics*, *72*(1), 80–99. https://doi.org/10.2307/3147159

Cattaneo, C. Internal and external barriers to energy efficiency: which role for policy interventions?. Energy Efficiency 12, 1293–1311 (2019). https://doi.org/10.1007/s12053-019-09775-1

Chapman, G. B. (1998). Sooner or later: The psychology of intertemporal choice. In D. L. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (pp. 83–113). San Diego, CA, US: Academic Press.

Chapman, G. B. (2000). Preferences for improving and declining sequences of health outcomes. *Journal of Behavioral Decision Making*, *13*(2), 203–218. https://doi.org/10.1002/(SICI)1099-0771(200004/06)13:2<203::AID-BDM317>3.0.CO;2-S

Davis, L. W., & Metcalf, G. E. (2016). Does better information lead to better choices? Evidence from energy-efficiency labels. *Journal of the Association of Environmental and Resource Economists*, *3*(3), 589–625. https://doi.org/10.1086/686252

Defra. (2010). *Behavioural economics & energy using products: scoping research on discounting behaviour and consumer reference points*. *Final Report*. London.

Department of Energy and Climate Change. (2014). *Evaluation of the DECC/Jhon Lewis energy labelling trial*. London: DECC. Retrieved from http://files/2081/John_Lewis_trial_report_010914FINAL.pdf

Ebeling, F., Lotz, S. (2015). Domestic uptake of green energy promoted by opt-out tariffs. *Nature Climate Change*, 5, 868–871. https://doi.org/10.1038/nclimate2681

Ebert, J. E. J., & Prelec, D. (2007). The Fragility of Time: Time-Insensitivity and Valuation of the Near and Far Future. *Management Science*, *53*(9), 1423–1438. https://doi.org/10.1287/mnsc.1060.0671

Enzler, H. B. (2013). *Future Orientation and Energy Saving - Subjective Discount Rates and Consideration of Future Consequences as Predictors of Environmentally Responsible Behavior*. Zurich.

Epper, T., Fehr-Duda, H., & Schubert, R. (2011). *Energy-Using Durables: The Role of Time Discounting in Investment Decisions*.

Faralla, V., Novarese, M., & Ardizzone, A. (2017). Framing effects in intertemporal choice: A nudge experiment. *Journal of Behavioral and Experimental Economics* , *71*, 13–25. https://doi.org/10.1016/j.socec.2017.09.002

Frederick, S., & Loewenstein, G. F. (2008). Conflicting motives in evaluations of sequences. *Journal of Risk and Uncertainty*, *37*(2–3), 221–235. https://doi.org/10.1007/s11166-008-9051-z

Frederick, S., Loewenstein, G. F., & O'Donoghue, T. (2002). Time Discounting and Time Preference: a review. *Journal of Economic Literature*, *XL*, 351–401.

Gerarden, T., Newell, R. G., & Stavins, R. N. (2015). *Assessing the Energy-Efficiency Gap* (Faculty Working Paper Series No. 2015–04). *ºStavins, Robert N.* Cambridge, Mass. https://doi.org/10.2139/ssrn.2554735

Goodkind, A. L., Tessum, C. W., Coggins, J. S., Hill, J. D., & Marshall, J. D. (2019). Fine-scale damage estimates of particulate matter air pollution reveal opportunities for location-specific mitigation of emissions. *PNAS*, *116*(18), 8775–8780. https://doi.org/10.1073/pnas.1816102116

Goodman, J. K., Malkoc, S. A., & Rosenboim, M. (2019). The Material-Experiential Asymmetry in Discounting: When Experiential Purchases Lead to More Impatience. *Journal of Consumer Research*, *46*(4), 671–688. https://doi.org/10.1093/jcr/ucz017

Granade, H. C., Creyts, J., Derkach, A., Farese, P., Nyquist, S., and Ostrowski, K. (2009). *Unlocking Energy Efficiency in the U.S. Economy*. Stamford, CT:McKinsey & Company.

Gromet, D. M., Kunreuther, H., & Larrick, R. P. (2013). Political ideology affects energy-efficiency attitudes and choices. Proceedings of the National Academy of Sciences of the United States of America, 110(23), 9314–9319. https://doi.org/10.1073/pnas.1218453110

Hall, Robert. 1997. The Inkjet Aftermarket: An Economic Analysis. Stanford University.

Hausman, J. A. (1979). Individual discount rates and the purchase and utilization of energy-using durables. *The Bell Journal of Economics*, *10*(1), 33–54. https://doi.org/10.2307/3003318

International Energy Agency. (2021). CO_2 Emissions Statistics. Retrieved March 8, 2019, from https://www.iea.org/statistics/co2emissions/

IPSOS, & London Economics. (2014). Study on the impact of the energy label and potential changes to it – on consumer understanding and on purchase decisions ENER/C3/2013-428 FINAL REPORT, (October), 141. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/Impact of energy labels on consumer behaviour.pdf

Kallbekken, S., Sælen, H., & Hermansen, E. A. T. (2013). Bridging the Energy Efficiency Gap: A Field Experiment on Lifetime Energy Costs and Household Appliances. *Journal of Consumer Policy*, *36*(1), 1–16. https://doi.org/10.1007/s10603-012-9211-z

Langbein, L. (2015). *Public Program Evaluation: A Statistical Guide* (First). London: Routledge.

Lewis, A. (2018). The Cambridge Handbook of Psychology and Economic Behaviour, 587. *Cambridge University Press*.

Loewenstein, G. F., & Prelec, D. (1991). Negative Time Preference. *The American Economic Review*, *81*(2), 347–352. Retrieved from http://www.jstor.org/stable/2006883

Loewenstein, G. F., & Prelec, D. (1993). Preferences for sequences of outcomes. *Psychological Review*, *100*(1), 91–108.

Loewenstein, G. F., & Sicherman, N. (1991). Do Workers Prefer Increasing Wage Profiles? *Journal of Labor Economics*, *9*(1), 67–84. Retrieved from http://www.jstor.org/stable/2535114

Lutz, J. D., Hopkins, A., Letschert, V., Franco, V. H., & Sturges, A. (2011). Using national survey data to estimate lifetimes of residential appliances. *HVAC and R Research*, *17*(5), 726–736. https://doi.org/10.1080/10789669.2011.558166

Magen, E., Dweck, C. S., & Gross, J. J. (2008). The hidden zero effect: Representing a single choice as an extended sequence reduces impulsive choice. *Psychological Science*, *19*(7),

Newell, R. G., & Siikamäki, J. (2015). Individual Time Preferences and Energy Efficiency. *American Economic Review*, *105*(5), 196–200. https://doi.org/10.1257/aer.p20151010

OECD. (2017). *Tackling Environmental Problems with the Help of Behavioural Insights*. OECD Publishing. Retrieved from http://www.oecd-ilibrary.org/environment/tackling-environmental-problems-with-the-help-of-behavioural-insights_9789264273887-en

Read, D., Frederick, S., Orsel, B., & Rahman, J. (2005). Four Score and Seven Years from Now: The Date/Delay Effect in Temporal Discounting. *Management Science*, *51*(9), 1309–1448.

Read, D., Olivola, C. Y., & Hardisty, D. J. (2017). The Value of Nothing: Asymmetric Attention to Opportunity Costs Drives Intertemporal Decision Making. *Management Science*, *63*(12), 4277–4297. https://doi.org/10.1287/mnsc.2016.2547

Rohling, M., & Schubert, R. (2013). Energy labels for household appliances and their disclosure format: A literature review. *IED Working Paper*, *21*, 10.

Schleich, J., Gassmann, X., Meissner, T., & Faure, C. (2019). A large-scale test of the effects of time discounting, risk aversion, loss aversion, and present bias on household adoption of energy-efficient technologies. Energy Economics, 80, 377-393. https://doi.org/10.1016/j.eneco.2018.12.018

Scholten, M., Read, D., & Sanborn, A. (2016). Cumulative weighing of time in intertemporal tradeoffs. *Journal of Experimental Psychology: General*, *145*(9), 1177–1205. https://doi.org/10.1037/xge0000198

Schubert, R., & Stadelmann, M. (2015). Energy-Using Durables: Driving Forces of Purchase Decisions. *Frontiers in Energy Research*, *3*(7), 1. https://doi.org/10.3389/fenrg.2015.00007

Skourtos, M., Damigos, D., Tourkolias, C. & Kontogianni, A. (2021). Efficient energy labelling: the impact of information content and style on product choice. Energy Efficiency 14, 58. https://doi.org/10.1007/s12053-021-09950-3

Stadelmann, M., & Schubert, R. (2018). How Do Different Designs of Energy Labels Influence Purchases of Household Appliances? A Field Study in Switzerland. *Ecological Economics*, *144*(August 2017), 112–123. https://doi.org/10.1016/j.ecolecon.2017.07.031

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The consideration of future consequences: Weighing immediate and distant outcomes of behavior. *Journal of Personality and Social Psychology*, *66*(4), 742–752. https://doi.org/10.1037/0022-3514.66.4.742

Taubinsky, D., & Allcott, H. (2013). The Lightbulb Paradox: Using Behavioral Economics for Policy Evaluation. *NBER Working Papers*, *19713*, 1–51. Retrieved from http://www.stanford.edu/group/SITE/SITE_2013/2013_segment_6/2013-segment_6_papers/allcott.pdf%5Cnfile:///Files/77/77A46F55-D2CA-4553-AFEC-2F1CF4A29C30.pdf

Train, K. (1985). Discount rates in consumers' energy-related decisions: A review of the literature. *Energy*, *10*(12), 1243–1253. https://doi.org/10.1016/0360-5442(85)90135-5

Tversky, A., Sattah, S., & Slovic, P. (1988). Contingent Weighting in Judgment and Choice. *Psychological Review*, *95*(3), 371–384. https://doi.org/10.1037/0033-295X.95.3.371

US Appliance Industry Saturation. 23rd Annual Portrait of The U S Appliance Industry Saturation. (2000). *Appliance Magazine*, *57*, 83–110. Retrieved from https://www.tib.eu/en/search/id/BLSE%3ARN084175500/23rd-Annual-Portrait-of-The-U-S-Appliance-Industry/

US Bureau of Labor Statistics. (2020). Consumer Expenditures in 2018. Retrieved July 8, 2020, from https://www.bls.gov/opub/reports/consumer-expenditures/2018/home.htm

US Energy Information Administration. (2020). Electric Power Montly. Retrieved July 8, 2020, from https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a

Waechter, S., Sütterlin, B., & Siegrist, M. (2015a). The misleading effect of energy efficiency information on perceived energy friendliness of electric goods. *Journal of Cleaner Production*, *93*, 193–202. https://doi.org/10.1016/J.JCLEPRO.2015.01.011

Waechter, S., Sütterlin, B., & Siegrist, M. (2015b). Desired and undesired effects of energy labels - An eye-tracking study. PLoS ONE., 10, e0134132. https://doi.org/10.1371/journal.pone.0134132

Weber, E. U., Johnson, E. J., Milch, K. F., Chang, H., Brodscholl, J. C., & Goldstein, D. G. (2007). Asymmetric Discounting in Intertemporal Choice. *Psychological Science*, *18*(6), 516–523. https://doi.org/10.1111/j.1467-9280.2007.01932.x

Wu, C.-Y., & He, G.-B. (2012). The Effects of Time Perspective and Salience of Possible Monetary Losses on Intertemporal Choice. *Social Behavior and Personality: An International Journal*, *40*(10), 1645–1653. https://doi.org/10.2224/sbp.2012.40.10.1645

2.8 Appendix

2.8.1 Annex 1. Spanish Pilot design and results

In this section, we report results from a study on a sample of 224 students at a Spanish university who were subjected to randomized treatments showing alternative framings of two refrigerators' energy requirements. Our treatments display information regarding the energy consumed by each refrigerator

in either i) *kWh*/year; ii) estimated electricity cost in € over the lifetime of the appliance; or iii) estimated electricity cost in € over the lifetime of the appliance with the addition of a message warning about the comparative long-term economic loss *(or gain)* compared to the alternative.

Differences in the samples and market context

There are considerable differences in the demographic compositions and in the cultural backgrounds in the tsamples used for the Spanish and for the US study. The first sample consisted of mainly Spanish 20-year-old students at a major public university, and the latter involved US adults with diverse socio-economic characteristics, in order to represent the entire US population.

In addition to this, there are country differences in the electrical appliances market and the relevant regulations. In the US, the average refrigerator size sold tends to be of a larger size compared with the ones sold in the Spanish market. US retailers also typically include a wider array of features in their product descriptions (including, for instance, handle color). Energy-efficiency labelling also differs across countries: In the European Union, countries' labels report annual electricity requirements in *kWh/annum* and assign an energy-efficiency rank to each appliance relative to similar ones in their category. In the US, the mandatory Energy Guide label incudes energy requirements in *kWh/annum* but also in estimated yearly operating costs.

There is also a substantial difference in electricity costs. The estimated average electricity price at the time of the experiment in the US was US$0.13/*kWh* (US EIA, 2020), whereas the corresponding price for the Spanish market was €0.20/*kWh.* This implies that, ceteris paribus, the electricity cost differential between efficient and inefficient appliances is higher in the Spanish market, and thus that energy efficiency is more convenient there.

Methods

In spring 2020, we administered the experiment to a sample of 224 undergraduate students at a Spanish university (50.4% female, mean age = 20.9 years). Before the start of their regular class, professors asked if they wanted to fill out an online survey to help a researcher in their university. Participation was voluntary, and they did not receive any payment or course credit. The assignment to a condition was randomized and so was the order of appearance of the appliances. After the experimental stimuli, we measured individual temporal orientation with elements of the Zimbardo temporal orientation scale (Zimbardo and Boyd, 1999). We also collected data on individual environmental orientation, expectations of future income and other demographic data.

We anticipated that undergraduate students usually did not receive a stable income and were unlikely to make major investments. Thus, we created a hypothetical income scenario a(s in Soman, 2001) in order to put the monetary sums involved into a context. They were told to imagine that their monthly income would allow them to save €150 per month and that they had €650 in savings immediately available. In order to make the trade-off between spending more money immediately or in the long term more tangible, they were also told that they had the option to go on a trip with a friend that same weekend at the cost of €300. The expenses were framed such that they could only afford the efficient appliance by renouncing the trip. Even though participants were unlikely to have purchased a refrigerator in real life, we expected any potential hypothetical bias to be evenly distributed across conditions and to be mitigated by the introduction of the income scenario in the experiment.

Results

We start by graphically illustrating our main results. In all conditions, the dependent variable is the proportion of participants choosing the green appliance. As shown in the figure below, this percentage increases from 65% in the control group to 79% in T2. A chi-squared test of independence shows that there is a significant association between T2 and green-appliance choice (compared with the Control

group). The chi-squared statistic is 3.8744, significant at $p < .05$. The difference between T1 and the Control group or T2 was instead not statistically significant.

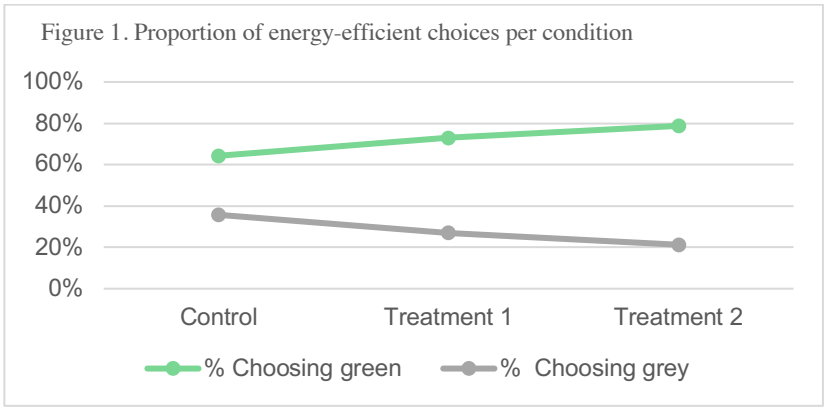


Figure A1. Proportion of energy-efficient choices per condition

Source: own computations based on experimental data

The temporal preferences survey allowed us to construct a continuous scale, the Future Orientation Scale (FOS), with higher values indicating that participants are more future-oriented (as in Tangari and Smith, 2012). A preliminary analysis of FOS shows that in each condition, participants choosing the green appliance had on average scored higher in future orientation (Table A1). This is valid across conditions; however, the differences in average FOS substantially decrease in T2. When individuals are reminded about the future implications of the available choices with a priming message, the effect of individual temporal orientation appears to vanish; the difference between average FOS lowers from 1.48 in the control group to just 0.28 points in T2. These differences are, however, not statistically significant (*p*-values from the F-test of the one-way ANOVA tests are all above 0.100).

Table A1 Spanish pilot. Average FOS per condition

	Participants choosing Grey	Participants choosing Green	Difference	Average FOS per condition	p-value form F test
Control	0.72 (0.94)	2.32 (0.57)	1.6	1.73 (0.50)	0.1312
Treatment 1	0.45 (0.99)	1.96 (0.51)	1.51	1.55 (0.46)	0.1491
Treatment 2	1.06 (1.23)	1.35 (0.68)	0.29	1.28 (0.59)	0.843
Totals	0.72 (0.59)	1.82 (0.35)	1.10	1.51 (0.30)	0.109

While random assignment of participants to groups presumably leads to homogenous groups, we calculated descriptive variables of the sample by group to ensure that these groups were balanced. Groups were homogenous with two slight exceptions (Table A2). First, in the operating-costs group, women were slightly underrepresented compared with others. Second, participants in the third group were from slightly wealthier families as the income scale was higher in the group. These differences are statistically significant at the 95% level as the *p*-values of the ANOVA test of equal variances (for the continuous variables) and the *p*-value of the Kruskal-Wallis test (for the ordinal variables) show. To account for these differences, we included these as covariates in our regressions.

Table A2. Main descriptive statistics of the sample by group

Variables	Control (1)	Operating costs (2)	Operating cost + relative loss message (3)	p-value form F test (4)
Median age	20.8 (s.d. $1.42e^{-16}$)	20.7 (s.d. $2.78e^{-17}$)	20.15 (s.d. $3.82e^{-17}$)	0.4607
Female (%)	58%	38%	55%	0.0318
Income (1 v. low – 5 v. high)	1.36 (s.d. 0.15)	1.42 (s.d. 0.17)	1.95 (s.d. 0.16)	0.0138
Family difficulty paying the bill sometimes/most of the times. (%)	40.6%	39.2%	27.5%	0.1794
Future Orientation Score (FOS)	1.74 (s.d. 0.5)	1.55 (s.d. 0.46)	1.29 (s.d. 0.59)	0.8322
Individual Responsible for the environment (1 agree –5 disagree)	4.14 (s.d. 0.1)	4.09 (s.d. 0.13)	4.06 (s.d. 0.12)	0.0822
Social Norm. most people would invest for greener products (1 agree –5 disagree)	2.32 (s.d. 0.12)	2.46 (s.d. 0.11)	2.35 (s.d. 0.12)	0.6744
Electricity CO_2 awareness (1 agree –5 disagree)	4.04 (s.d. 0.11)	3.96 (s.d. 0.13)	4.19 (s.d. 0.12)	0.3913
In the next years my income will worsen (%)	4.3%	9.5%	7.5%	0.4951
N. participants	69	74	80	

We estimate regressions of the form:

$$Y_{(i,t)} = \beta \cdot Treatment_{1(i)} + \gamma \cdot Treatment_{2(i)} + \delta \cdot FOS_{(i)} + \theta \cdot Treatment_{1(i)} \cdot FOS_{(i)} + \vartheta \cdot Treatment_{2(i)} \cdot FOS_{(i)} + a_{(i)} + \varepsilon_{(i,t)} \quad (2)$$

where the dependent variable $Y_{(i,b)}$ represents the appliance chosen by participant i. This variable is a 0–1 dummy variable, set to 1 if the participant chose the efficient appliance and 0 otherwise.

The main explanatory variables of interest are $Treatment_{1,2(i)}$. They are 0–1 dummy variables, equal to 1 if the participant was in T1 or T2, respectively. The value equals 0 otherwise. The estimated β and γ coefficients represent the percentage difference in the likelihood of a participant choosing the energy-efficient appliance compared with the control group, after controlling for other covariates.

$FOS_{(i)}$ is a 0–32 scale measuring individuals' temporal orientation; the higher the value, the more future-oriented the individual is. Additionally, we look for interaction effects between the treatments' variables and $FOS_{(i)}$.

$a_{(i)}$is a vector consisting of individual-level and state-level socio-demographic as well as individual environmental-orientation controls. These controls increase the precision of our estimates and correct for the slight socio-demographic imbalances observed between groups. The controls included are:

i. age, gender, income, and nationality;
ii. economic indicators:
    a. income scale;
    b. whether the person expects the economy to worsen in the future;
    c. whether the person experienced problems paying bills often; and
    d. whether the person lives in a rented flat.

iii. environmental orientation:
    a. whether the person feels personally responsible for caring for the environment;
    b. whether the person thinks most people would pay more for environmental preservation; and
    c. whether the person believes electricity use to be an important component of CO_2 emissions.

The results of our estimations are reported in Table A3.

TABLE A.3 Regressions output

	Logit					Mar.eff. at the means	Control	Treat. 1	Treat. 2	Control	Treat. 1	Treat. 2
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Treatment 1: operating costs info (dummy)	0.466	0.467	0.425	0.479	0.615	0.056						
	(0.366)	(0.367)	(0.387)	(0.410)	(0.410)	(0.077)						
Treatment 2: operating costs info + patience inducing message (dummy)	0.801**	0.845	0.893**	0.778*	0.687*	0.118*						
	(0.376)	(0.748)	(0.395)	(0.412)	(0.407)	(0.071)						
FOSH scale 1–4	0.265**	0.272*			0.261*		0.470*	0.045	0.246			
	(0.136)	(0.166)			(0.147)		(0.270)	(0.285)	(0.254)			
FOSH x Treatment 2		-0.020										
		(0.293)										
"I prefer to spend today what I earn rather than saving for tomorrow" Disagree-Agree (1–5)										-0.719***	-0.254	-0.138
										(0.300)	(0.269)	(0.257)
FOS 1st quartile			*(omitted)*	*(omitted)*								
FOS 2nd quartile			1.065***	1.130**		0.221*** [c]						
			(0.451)	(0.475)		(0.087)						
FOS 3rd quartile			0.705*	0.822**		0.138 [c]						
			(0.428)	(0.464)		(0.095)						
FOS 4th quartile			0.812*	0.804*		0.188** [c]						
			(0.430)	(0.461)		(0.090)						
Pessimist beliefs about future income (dummy)				-0.1267**	-1.995***	-0.293**	*(omitted)*	-1.532*	0.455	*(omitted)*	-1.674*	0.391
				(0.587)	(0.765)	(0.166)		(0.944)	(1.149)		(0.958)	(1.148)
Pess. beliefs x Treatment 2					2.200* [a]							
					(1.380)							
Frequent difficulty paying bills in the family (dummy)				-1.011***	-0.852***	-0.235***	-0.908	-0.939	-0.631	-0.893	-0.944	-0.620
				(0.362)	(0.345)	(0.082)	(0.593)	(0.678)	(0.654)	(0.610)	(0.680)	(0.650)
Rent (dummy)				-0.716*	-0.762*	-0.155	-0.768	-0.1.513*	0.096	-0.378	-1.468*	0.219
				(0.446)	(0.426)	(0.101)	(0.728)	(0.875)	(0.881)	(0.763)	(0.839)	(0.868)
Demographic controls (sex, age, income, nationality)	N	N	Y	Y	Y		Y	Y	Y	Y	Y	Y
Environmental Values controls	N	N	N	Y	N		N	N	N	N	N	N
Observations	223	223	223	223	223		66	74	80	66	74	80
Pseudo R-squared	0.030	0.030	0.068	0.127	0.114		0.142	0.156	0.042	0.179	0.167	0.033
P-value F test	0.045	0.090	0.086	0.009	0.0047		0.103	0.095	0.903	0.036	0.072	0.949

Note.

[a] P-value F test nearly statistically significant at 0.111.

* Significant at <.10, ** significant at <.05, *** significant at <.01. Standard errors in parentheses.

In column 1, we find that *T1*—i.e., merely expressing energy cost in total € over 10 years of use—is not statistically significant. *T2*—i.e., adding a message highlighting the relative future losses compared with the other appliance—is statistically significant at the 95% confidence level. The coefficient shows that being in this group increases the likelihood of choosing the green appliance.

Additionally, more future-oriented individuals are more likely to choose the efficient appliance for every additional point in the FOS scale from 1 to 4. These results are robust to the addition of demographic controls and even when we used an alternative method to include the FOS scale (using quartile dummies instead of a scale), as seen in column 3. In column 2, we estimated the interaction effect between T2 and the FOS scale, but the effect was, however, not statistically significant. We did not report the interaction effect between T1 and the FOS scale since that treatment was not statistically significant.

In column 4, we include dummies capturing whether: i) the individual expects income to decrease in the near future; ii) the individual's family has experienced frequent difficulties paying bills in the last month; and iii) the individual lives in a rented apartment. These three coefficients are statistically significant and negatively affect the likelihood of buying the green appliance. The F-test for the goodness-of-fit of the model shows a p-value < 0.01, and it contributes to explaining 12.7% of the variation observed. This level of R^2 is similar to that of other papers in the field, and it is considered an acceptable level, given the complexity of human behavior (Langbein, 2015).

In column 5, we add an interaction effect between T2 and pessimistic beliefs about future income. The effect is statistically significant and has a positive sign. The effect more than counterbalances the negative effect of pessimistic expectations about future income. It indicates that although these subjects would normally be less inclined to pick the efficient fridge, reminding them about the stream of future savings is enough to change their choices. The coefficients of the other controls listed and additional regressions including interaction effects (between T2 and Rent and DifficultyPayingBills) were not included in this table because they were not statistically significant in any of the regressions. In column 6, we compute the marginal effects of the explanatory variables on the likelihood to choose the green appliance. We find that being in T2 increases the chances that a hypothetical average individual will choose green appliances by 12%. The same individual will be 29% and 23% less likely to choose green appliances if he or she expects income to deteriorate in the future and if his or her family is facing economic constraints. The probability of choosing green appliances increases with each additional point in the FOS scale, although at a marginally decreasing rate.

We further investigated whether being in a particular treatment affected the relevance of individual temporal orientation. We thus ran the same model with split regressions by condition, using two alternative measures of temporal orientation: i) FOS measured on a 1–4 scale; and ii) using participants' response to "I prefer to spend today what I earn rather than saving for tomorrow" on a Likert scale with 1 = Totally Disagree to 5 = Totally Agree.

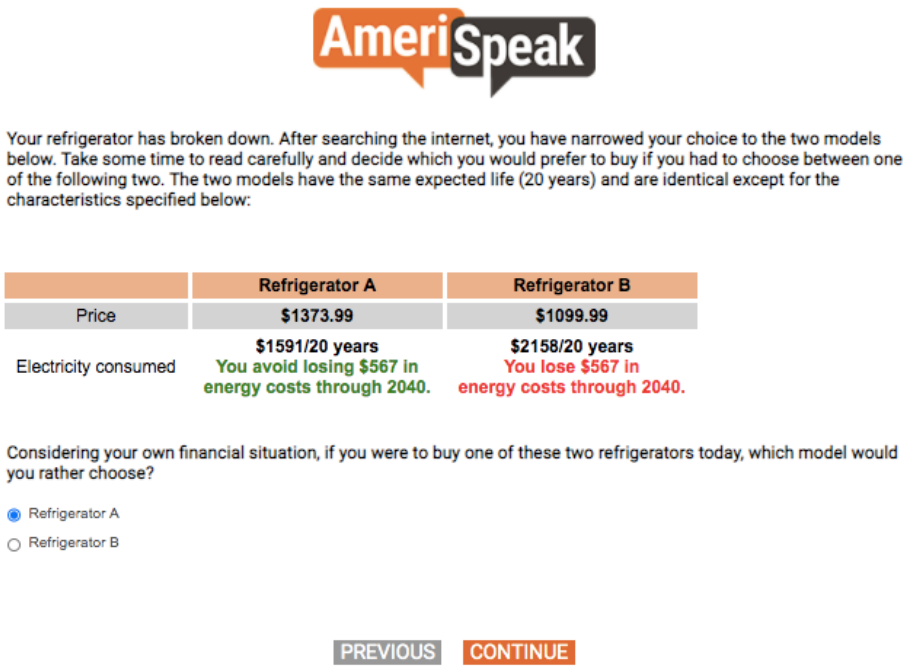
We begin noting that regardless of the measure of temporal orientation we choose, FOS is effective only in the control group. In the two treatments, individual temporal preferences are not relevant anymore, thus indicating that revealing future operating costs erases the impact of individual temporal preferences on appliance choice. This finding is relevant as it shows that providing a specific kind of information can counteract temporal preferences that would otherwise influence choice by default.

Expectations that income will decrease in the future lower the likelihood of choosing the green appliance in T1 (columns 8 and 11). Presumably, people who think income will decrease in the next five years prefer to save money immediately rather than later in normal conditions. When they are also primed with a future-oriented message in T2, this effect disappears entirely (coefficients are not statistically significant). We thus believe that the effectiveness of T2 is delivered through two mechanisms: It lowers impatient choices by counteracting the individual's default temporal preferences, but it also redirects the attention of people worried about their future income towards the potential future loss from choosing the less efficient appliance.

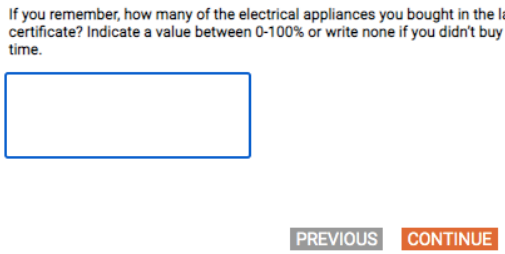
2.8.2 Annex 2. Full Survey United States

This survey was administered together with two other surveys.

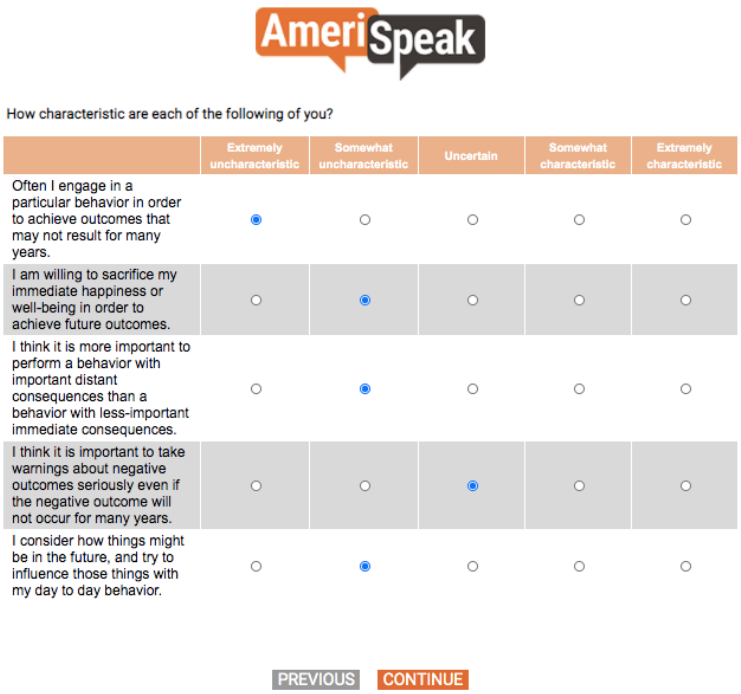
I. Experimental stimulus, subjects are exposed to one of the 6 conditions highlighted in Table 2 of the paper.



II. Participants are then asked to reveal their actual previous energy efficient appliance purchases.



III. They were then asked to fill in a 5-items matrix measuring their temporal orientation, using the future-orientation elements of the CFC scale.

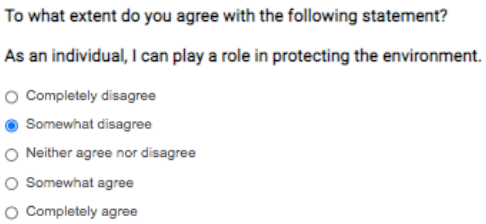


How characteristic are each of the following of you?

	Extremely uncharacteristic	Somewhat uncharacteristic	Uncertain	Somewhat characteristic	Extremely characteristic
Often I engage in a particular behavior in order to achieve outcomes that may not result for many years.	◉	○	○	○	○
I am willing to sacrifice my immediate happiness or well-being in order to achieve future outcomes.	○	◉	○	○	○
I think it is more important to perform a behavior with important distant consequences than a behavior with less-important immediate consequences.	○	◉	○	○	○
I think it is important to take warnings about negative outcomes seriously even if the negative outcome will not occur for many years.	○	○	◉	○	○
I consider how things might be in the future, and try to influence those things with my day to day behavior.	○	◉	○	○	○

PREVIOUS CONTINUE

IV. They were then asked their perception of their own role in protecting the environment.



To what extent do you agree with the following statement?

As an individual, I can play a role in protecting the environment.

- ○ Completely disagree
- ◉ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Completely agree

CONTINUE

V. Participants in the AmeriSpeak panel are usually required to answer a set of other standard questions in order to be part of the panel, along with other socio-economic-demographic data. These answers to these questions can eventually also be used by experimenters. To the purpose of this experiment, we used answers to the following three questions:

V.1. Expectations of future income: "Now looking ahead, do you think that a year from now you and your family living in your household will be financially…?"

1 Better off as now?
2 About the same as now?
3 Worse off as now?

V.2. Financial literacy: “Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow:”

1 more than $102
2 exactly $102
3 less than $102

V.3. Saving habits: " Which of the following best describes your saving habits?"

1 Don’t save, usually spend more than income
2 Don’t save, usually spend about as much as income

3 Save whatever is left over at the end of the month
4 Save regular income of one family member, spend the other
5 Spend regular income, save other income

VI. Save regularly by intentionally putting aside money each month

3

The public acceptability of carbon taxes: an intertemporal perspective

Abstract

The literature on carbon taxes has extensively investigated how individual characteristics and distinct policy features, such as tax rate and use of revenues, affect public acceptability of such taxes. Yet it has largely ignored the intertemporal nature of these instruments. Carbon taxes require individuals to sacrifice current wellbeing by paying a tax today for environmental benefits which will mostly be shared and enjoyed in the future. In this paper, we investigate whether the temporal distribution and perception of the sacrifices and rewards of carbon taxes can be altered to increase their public acceptance. In a hypothetical choice experiment on a nationally representative sample of 1,000 United States adults, we presented individuals with six temporal carbon tax formulations that either started immediately or had a delayed start of three to six years with environmental carbon abatement objectives expressed either by 2030 or 2050. We found statistically significant increases in tax acceptance for carbon tax designs that are postponed a few years into the future and that express their environmental objectives in more long-term and ambitious (2050) goals. Once the price of a carbon tax is adjusted upward to compensate for the delay in its introduction, however, individuals start trading off the delay in the introduction of the tax with avoidance of tax increases. Our findings show that when individuals are informed of the economic opportunity cost of delaying the tax, they are not willing to postpone it indefinitely. Individual discounting, exogenously measured, affects tax acceptance.

Keywords

carbon tax, public acceptability, temporal preferences, intertemporal choice, survey experiment

3.1 Introduction

Most collective dilemmas—that is, situations in which private interests contrast with collective interests—have an embedded intertemporal component in that they often imply that the rewards from defection are immediate but the rewards from cooperation are delayed and often accrue to people in the future. This is particularly relevant in the context of natural resources preservation and to the climate commons—intended as "the global public good of climate change mitigation" (Carattini et al., 2019, p. 227)—since individuals must sacrifice current wellbeing for benefits which will mostly be enjoyed by future generations, which undermines political support in favor of climate regulation (Gollier, 2020).

To achieve successful cooperation in intertemporal environments, it is crucial to understand: a) the influence that the temporal context of the decision has on decision outcomes; b) the role individual time preferences and altruism play in the decision to cooperate; and c) the interplay between individual temporal preferences and the temporal context. In this paper, we focus on the public acceptability of a carbon tax and explore a new dimension in the literature: What is the temporal formulation of a carbon tax that maximizes its acceptability?

Carbon pricing is commonly regarded by economists as the most efficient and effective climate mitigation policy (either through carbon taxes or emission trading systems; Baranzini et al., 2017). However, most world emissions are still not affected by a carbon pricing instrument. The reluctance of politicians to adopt carbon taxes has been linked, among other things, to their unpopularity among voters, who notably perceive them as too coercive in comparison to "pull measures" such as subsidies. This paper investigates whether the temporal contextualization of carbon taxes can be adjusted to make them more popular.

We undertook a hypothetical choice experiment in which a nationally representative sample of 1,000 US adults voted in favor or against the introduction of alternative carbon tax designs which were characterized by different introduction dates (immediate, three or six years delay) and different temporal horizons (emission cuts are expressed either in 2030 or 2050 objectives). Additional policy attributes included revenue use, percentage of expected CO_2 emission cuts, taxation levels, and the estimated cost and revenues the tax may impose on households. To increase the salience of the experiment and its external validity, we customized choice cards within the survey rather than just showing average cost estimates, with ad-hoc calculations of the economic impact of the policy based on each participant's declared income.

We separately measured individual temporal preferences using a multi-pricelist experiment and analyzed whether or not more present-biased individuals are more likely to accept the tax in any given scenario. This allows us to disentangle the effects of temporal strategy from individual temporal preferences; for example, impatient individuals may prefer earlier rewards and to postpone sacrifices, whereas more future-oriented individuals or altruistic individuals may be more eager to commit to larger later rewards which are shared in the future between themselves and the next generations. With policy relevance in mind, we include carbon taxation prices that are deemed to be in the range of compatibility with the Paris Agreement objectives of maintaining global warming within 1.5ºC above pre-industrial levels. Additionally, we look at the impact of different temporal contextualizations on population groups that are found to be more opposed to the tax: climate change deniers and individuals with conservative political values who distrust public institutions and who reject any personal responsibility to care for the environment.

The rest of the paper is articulated as follows. Section 2 introduces the state of the relevant literature on intertemporal choice and on the acceptability of carbon taxes. It also provides context to legislation and public opinion on carbon taxes in the United States. Section 3 describes the experimental design and how the survey and the analysis were structured. Section 4 presents the results through qualitative and econometric analyses. Section 5 summarizes our key findings and conclusions.

3.2 Background

3.2.1 Literature review

3.2.1.1 Intertemporal choice

The temporal dimensions of collective dilemmas and of the acceptability of carbon pricing are surprisingly unexplored. A theoretical framework developed by Hedrickx et al. (2001) identified four temporal dimensions that are relevant and which influence cooperation in resource pool dilemmas: individual discount rates, the resource pool's temporal horizon, its growth rate, and the delay between extraction decisions. However, empirical evidence to date on the influence of these factors on the likelihood of cooperation is fragmentary. Earlier research has highlighted that individual discounting correlates negatively with cooperation, suggesting that the temptation to free ride may be stronger for more impatient individuals (Mannix, 1991; Curry et al., 2008; Fehr & Leibbrandt, 2011). Research that has analyzed the influence of the temporal horizon of choice highlights that the longer people feel invested in a community, the more they will be willing to cooperate for its common good. For instance, Mannix & Loewenstein (1993) found that managers who anticipated that they would stay longer in the same role would contribute more to a public organizational fund. Additional experimental research has shown that cooperation becomes more unlikely as the gains from cooperation are shifted further away in time (Jaquet et al., 2013). Arora et al. (2012) found that when the consequences of a decision are shifted to the future—such as whether or not to donate to an investment cooperative if the payment is delayed by six months—individuals tend to show higher cooperation compared to when they face the immediate consequences of their choices. In addition, precommitment mechanisms are one of the most known mechanisms to induce individuals to avoid present bias and invest in their future wellbeing both academically and in the established practice, for instance, by enrolling in saving schemes (Thaler & Benartzi, 2004; Benartzi & Thaler, 2013).

The available evidence thus suggests that the default temporal setting in which the costs of cooperation are immediate and gains are delayed undermines the possibility of cooperation. Can asking people to commit to a carbon tax that starts a few years from now increase its public support by shifting the costs it imposes to households in the future? Are individuals more likely to accept it if the gains from cooperation—in terms of future carbon emissions cuts—are expressed by a more proximal date? Do present- and future-focused individuals have similar preferences regarding the temporal distribution of the sacrifices and rewards of a carbon tax? The extent to which the temporal distribution of costs and gains can be manipulated to increase cooperation has not been systematically studied; nor are the interactions between individual time preferences and the contextual temporal setting known.

3.2.1.2 Carbon tax acceptance

The literature on the acceptability of carbon taxes has analyzed the impact of individual characteristics, contextual factors, and different policy designs on various geographical settings, mainly through stated preferences approaches (Drews & Van den Bergh, 2015). Common findings that are relevant to our study indicate that people tend to overestimate carbon tax costs and underestimate their effects (Douenne & Fabre, forthcoming), that tax acceptability decreases with the personal costs associated with it, and that tax resistance decreases after people have experience with the tax (for a review, see Carattini et al., 2019). Several studies and opinion polls have indicated a marked preference for the earmarking of revenues: individuals are more favorable to carbon taxes when revenue use is destined to finance other environmental mitigation activities, to reduce other taxes, or for redistributions in the form of cash-back payments as opposed to when the use of the revenues is not mentioned (Bachus et al., 2019). Support for carbon taxes also depends on the level of trust in political institutions (Savin et al., 2020) and knowledge about climate change (Douenne & Fabre, forthcoming).

To date, only one experiment has looked into the relationship between acceptability and the temporal context of an environmental tax. In a laboratory experiment with 218 students, Tiezzi & Xiao (2016) undertook an intertemporal market experiment based on auctions of an externality-producing good. They surveyed how support for the introduction of an environmental tax to account for the externality changed as a function of the timing of the externality. They found that environmental taxes were less likely to be approved when the externality materializes after the good that produces them has been traded and consumed. They also concluded that in real life, individuals are equally less likely to support environmental taxes when the externality they aim to reduce is not readily visible to them; for example, the benefit of consuming gasoline is experienced immediately whereas its externality, that is, pollution, accumulates over time.

3.2.2 The national context in the United States

The United States (US) is a signatory of the Paris Climate Agreement and has committed to reaching net zero emissions economy-wide by 2050. In addition, it has pledged to cut its national greenhouse gas emissions by 50–52% by 2030 compared to 2005 levels as part of its Nationally Determined Contribution (The White House, 2021). Different forms of carbon pricing programs have been independently adopted by 13 of its 50 States, starting with the Regional Greenhouse Gas Initiative in 2005 (which involved 11 states on the northeast coast) and followed by California's cap and trade program in 2013 and the State of Washington's Climate Commitment Act, set to start in 2023 (Center for Climate and Energy Solutions, 2021).

At the federal level, five concurrent carbon pricing designs have been introduced in the 117th Congress between 2019 and the first half of 2021. They vary in terms of emissions covered, taxation level, and revenue use. The increasing presence of carbon pricing in the political debate is mirrored by an increase in public support for these policies, as reported by opinion polls. The percentage of Americans who support the introduction of a carbon tax stood at 36% in 2009 and it has gradually increased to 50% in 2016 (Puskin & Mills, 2017). The highest support was registered in 2020, with 68% of registered voters in support of requiring fossil fuel companies to pay carbon taxes (Leiserowitz et al., 2020). Support for a carbon tax is a politically divisive topic, with two-thirds of Democrats in favor of it and just 30% of Republicans in support of it when the revenue use is not mentioned. The political divide, however, becomes narrower and overall support increases when tax revenues are earmarked to support further mitigation activities or to lower other taxes (to 45% of Republicans and up to 77% of Democrats; Leiserowitz et al., 2021).

Given the increasing political debate about carbon taxes and the consequent relevance and familiarity of the subject to Americans, the United States offers an ideal landscape in which to test the acceptability of different carbon tax formulations. The concrete carbon tax designs to be discussed in the current US Congress enable us to replicate some key features of some of these designs. Concurrently with our core stated objective of testing the relevance of the temporal context in the acceptance of a carbon tax, this enables us to provide information on the political feasibility of some of the current policy designs in the United States.

3.3 Methods

3.3.1 Experimental design

The experiment is designed as an online survey in which a nationally representative sample of the US population expresses how they would vote on a national referendum in support of the introduction of a tax on CO_2 emissions. Our survey was developed using the survey software Qualtrics and it was administered through Prolific Academic. Prolific Academic is a widely used panel for academic research that allows sampling of representative members of the US population. It has also been recommended for delivering

higher quality data compared to alternative platforms (Palan & Schitter, 2017; Peer et al. 2017). The experiment aims to investigate whether support for this policy is sensitive to changes in the start year of the policy and its temporal horizon. We thus created six temporal scenarios, identified by all possible combinations between three alternative policy start dates and two alternative temporal horizons by which the CO_2 emissions cuts are expressed. These six scenarios are tested twice, once with unspecified revenue use and once with revenue use earmarked as cashback payments to constituents. The resulting 12 possible combinations define the many treatment groups described in Table 3.1.

TABLE 3.1 Treatments (combinations)

Implementation date of the policy	Avoided CO_2 emissions: By 2030		By 2050	
Immediate (2021)	1	2	7	8
In three years (2024)	3	4	9	10
In six years (2027)	5	6	11	12

Revenues as Cashback
Basecase, revenues to the general budget

In summary, the proposed experiment follows a 2x3x2 factorial between subject design which identifies 12 treatments.

i) One factor pertains to the immediacy of costs and of the cashback payments (policy start date set to 2021, 2024, or 2027).
ii) One factor pertains to the immediacy of the environmental rewards (emissions abatements targets are expressed by either a 2030 or a 2050 goal).
iii) One factor pertains to whether revenue use is either unspecified (Basecase) or earmarked for redistribution (Cashback).

The experiment follows a split sample design (as per Grammatikopoulou et al., 2020) to avoid anchoring effects. One respondent is assigned to just one cost/reward temporal combination/revenue use condition. Participants answer a sequence of questions consisting of four choice tasks[14] framed within the same temporal context but with varying levels of other policy attributes. In particular, they vote on progressively increasing tax levels which are reflected not only in higher costs imposed on the average household but also in higher carbon emissions abatement targets to be achieved by the tax. To minimize sequencing effects, we disclose at the beginning of the survey the number of choice sets with which participants will be presented (Bateman et al., 2004).

3.3.1.1 External validity and hypothetical bias

We designed the survey with external validity in mind. In particular, we informed participants that the survey was part of a study that would potentially inform the government of the likelihood of success of a referendum about the introduction of a CO_2 tax. As Arrow et al. (1993) observed, referenda on the provision of public goods are not uncommon, and practitioners (Bishop & Boyle, 2019), including the National Oceanic and Atmospheric Administration (NOAA) panel on contingent valuation, recommend the use of a referendum format to make the choice more realistic. Five studies which compared the outcome of contingent valuation surveys formulated as referenda found that they performed well in comparison to

[14] Based on Louviere et al. (2000) who recommend not to exceed choices to 4 questions.

actual voting (Bishop & Boyle, 2019). This context also makes the study incentive compatible, meaning it is a context in which the optimal strategy for the participant is to give a true representation of her/his preferences. In particular, participants have an incentive to truthfully reflect their preferences in the survey if (a) they see the survey results as an opportunity to influence business or government actions and (b) they care about the outcomes of those actions (Carson & Groves, 2007). We clearly stated that the survey can inform the government with respect to the viability of adopting a CO_2 tax, and we also assumed that most adults care about either or both of the issues of global warming or an increase in their annual costs (the latter depending on income levels).

A novel feature of our survey design is that it introduced a personalized estimate of the potential cost and eventual carbon dividend payment to which the individual household would be entitled based on the income declared by the participant. This design feature enabled us to overcome biased expectations and to elicit preferences that were based on more accurate economic expectations and, thus, were closer to predicting the actual reactions that individuals would have in real life when facing the economic consequences of the tax.

Concerns about external validity also guided the number of choice options shown in each choice set. In similar, related studies, researchers have chosen to include three or more choice alternatives as a way to maximize the amount of information gathered from a small sample; that is, to elicit both the likelihood that a policy would be accepted against the status quo and the relative preference between different policy alternatives. In contrast, we chose to present participants with just two choice options—the status quo and one policy alternative—for three reasons:

a) According to the mechanism design theory by Gibbard (1973) and Satterthwaite (1975), only binary response formats can be incentive compatible and thus induce participants to realistically represent their choices.[15]
b) The number of alternative options included in a choice set has been found to affect answers in several convergent validity studies (see a review in Weng et al., 2021). Measured willingness to pay in contingent valuation surveys and response rates varies depending on whether respondents reply to a binary-choice question in which one option is the status quo and the alternative is the introduction of an environmental policy or they reply to a multiple-choice question format in which status quo and a number n>1 of alternative policies are considered. Recent empirical (Weng et al., 2021) and theoretical (Carson & Groves, 2007) studies and the NOAA panel on contingent valuation recommend a binary elicitation format to reduce anchoring and other sources of bias typical of multiple-choice questions (Arrow et al., 1993, p. 53).
c) A survey that reproposes the choice elicitation method of the context it wants to mimic is more relatable to participants, and their results should be more realistic and credible (Carson & Groves, 2007). Since actual referenda use a binary format, it seems logical to reproduce it in our survey.

We, therefore, expect the binary elicitation format to be the one that records stated preferences which are closer to real-world choices. To further minimize the risk of hypothetical bias and in accordance with best practices, we added a follow-up question after the experiment, asking respondents to rate how certain they were of their responses as a measure of the questions' external validity (Johannesson et al., 1999; Brouwer et al., 2009). We also gave respondents the possibility to answer "Don't Know" to the experimental choices. This enables us to calibrate the analysis towards greater accuracy.

[15] For example, when participants are presented with more policy alternatives, they may infer that there is uncertainty about the cost of a given policy, and they may be induced not to reveal their true preferences (e.g. they may try to induce the government to supply the good at the lowest price, even if their actual willingness to pay was higher than they indicate) (Carson & Groves, 2007).

Prior to the survey, we provided a simple introduction of the link between the use of fossil fuels, CO_2 emissions, and global warming as well as how a carbon tax could address the problem. We also reminded participants of the expected temperature increase in the United States should global greenhouse gas emissions continue on the current path, and we informed them of the national commitment the US government has made to decrease its emission trajectory. Following the NOAA's recommendations, we also reminded individuals of their budget constraints and of expenses they may have to renounce to pay for the policy's costs.

3.3.1.2 Policy attributes

Table 2 summarizes the policy attributes used to describe the tax and their consequences on the different scenarios. Each attribute has several levels, and attributes are interlinked with each other. We considered three different *Policy Start Dates* with three years in between them, 2021 (immediate), 2024, and 2027. By including three-year delays, we modeled for a date which is far enough in the future in the constituents' minds yet still possibly within a government's electoral mandate. By including a 6-year delay scenario, we evaluated the possibility for a government to introduce a tax that will only be effective in the next political mandate.

We defined *Tax Levels* expressed in US$/$tCO_2$ that are either below or within the price range that is considered necessary to reach the Paris Treaty objectives of staying within 1.5–2 ºC of global warming by the end of this century. The estimation of the tax levels needed to achieve these scenarios has been the subject of several modeling exercises. These exercises have estimations that vary widely and depend on a variety of factors—such as different baseline assumptions and a wide range of pessimist/optimist expectations regarding technological improvements and policy contexts. Adding to this rich literature is beyond the scope of this paper. In defining taxation levels for the experiment, we relied on the Stiglitz-Stern review of existing carbon price estimates and, in line with their analysis, we considered the explicit carbon price consistent with Paris temperature targets to be between US$40–80/$tCO_2$ by 2020 and US$50–100/$tCO_2$ by 2030 (High-Level Commission on Carbon Prices, 2017). We also included a tax equal to US$15/$tCO_2$, which is the taxation level proposed in the Energy and Dividend Act bill. More specifically, we considered a carbon tax at US$ 15, 40, 60, and 80 per tCO_2 for policies starting in 2021. We considered that the range in the level of taxation so defined should be the most relevant for policymakers. Estimates of tax levels compatible with global temperature scenarios are usually calculated using 2020 as a baseline and they then gradually increase. The Energy and Dividend Act bill is also set to increase the tax by a minimum of US$10 per year. For the scenarios in which the tax introduction is delayed to 2024 or 2027, the starting tax level is higher to account for this planned yearly increase and is further augmented to make up for the years of missed emissions cuts and, consequently, a narrower carbon budget. More specifically, we increased the planned starting fee by 3.9 percentage points for every year of delay[16]. The resulting tax fees for the delayed scenarios are reported in Table 2. At the start of the survey, participants were required to insert their household annual income, and this information was used to compute in real time the estimated cost and revenue that the participant would likely face in real life as a consequence of the tax.

Cost of the tax to households. Our computations of the costs and revenues to specific households are based on a study (Ummel, 2020) which focused on the distributional implications of a carbon fee and dividend

[16] This estimate is based on from Furman et al. (2015), who conducted a meta-analysis of 16 integrated climate mitigation models and found that, on average, a decade of delay in the implementation of climate mitigation policy reflects in an average increase in abatement costs by 39%. An alternative estimate by the Brookings Institute finds that delaying the introduction of a carbon tax at US$ 15 in the US economy would require on average a total increase in the tax by nearly 9% per year of delay to achieve the same cumulative emissions were the tax to start immediately (Mckibbin et al., 2014). Adjusting tax levels for 2024 and 2027 using this second method leads to comparable results with only minimal variations within the range of US$ 0–2.

policy on American households. Using a simulation of household-level effects (from the American Community Survey and the Consumer Expenditure Survey) and input–output data from the Bureau of Economic Analysis, the study calculated the average yearly financial impact that a US$15/tCO$_2$ tax would have on American families in each income quintile[17]. We used this study as a benchmark to generate within the survey a personalized estimate of cost implications for each participant, using a) his/her household income, b) the average consumption of people in the same income quintile, and c) the tax level considered on the choice card[18]. We insured that the costs assigned to each tax level were internally consistent—higher tax levels corresponded to higher costs to the household. The same study also defined the *potential revenues* that would be redistributed to families based on their income quintile based on the assumption that revenues were redistributed as dividends. We thus used these calculations to calculate the cashback revenue to which the participant household could potentially be entitled in the Cashback condition. The range of values of the costs and revenues from the tax are included in Table 3.2.

TABLE 3.2 Policy attributes and levels

Attributes	Status Quo	Levels
1. Policy start date	never	2021, 2024, 2027
2. Tax level *(not shown on choice cards)*	0US$/tCO$_{2\%}$	Tax levels for policy start in 2021: 15, 40, 60, 80 US$/tCO$_2$ • three are compatible with the Paris Agreement objectives, although with differing degrees of certainty. • and one is potentially below. Tax levels adjusted for policy start delayed to 2024: 50, 67, 75, 100 US$/tCO$_2$ Tax levels adjusted for policy start delayed to 2027: 62, 93, 123, 130 US$/tCO$_2$
3. Cost of the tax for the household	0 US$/year	The value is calculated within the survey and it depends on the tax level and the household income declared by the participant. It ranges between 0.01–1400 US$/year.
4. Revenue of the tax for the household *(Cashback condition only)*	0 US$/year	The value is calculated within the survey and it depends on the tax level and the household income declared by the participant. It ranges between 0.07–773 US$/year.
5. % change in national emissions *(Compared to 2005 levels)*	National emissions to decrease by: • 14% (2030) • 25% (2050)	Depends on the tax level and the temporal horizon considered: • 20–75% (2030) • 60–130% (2050)
6. Temporal horizon by which emissions cuts are expressed	2030, 2050	2030, 2050

[17] The study focuses on the distributional implications of one of the five bills currently in Congress, namely the Energy Innovation and Carbon Dividend Act of 2021 (H.R. 2307).

[18] More specifically, we multiplied the participant income by the average % income loss that corresponds to her/his income quintile (as estimated by Ummel, 2020) and divided the amount by US$15 to obtain the cost to that specific household of each US$1 of carbon tax; we then multiplied such amount by the tax level considered on the choice card.

FIGURE 3.1.A Introduction and Choice task ex. Basecase, with start in 2024 and 2030 horizon

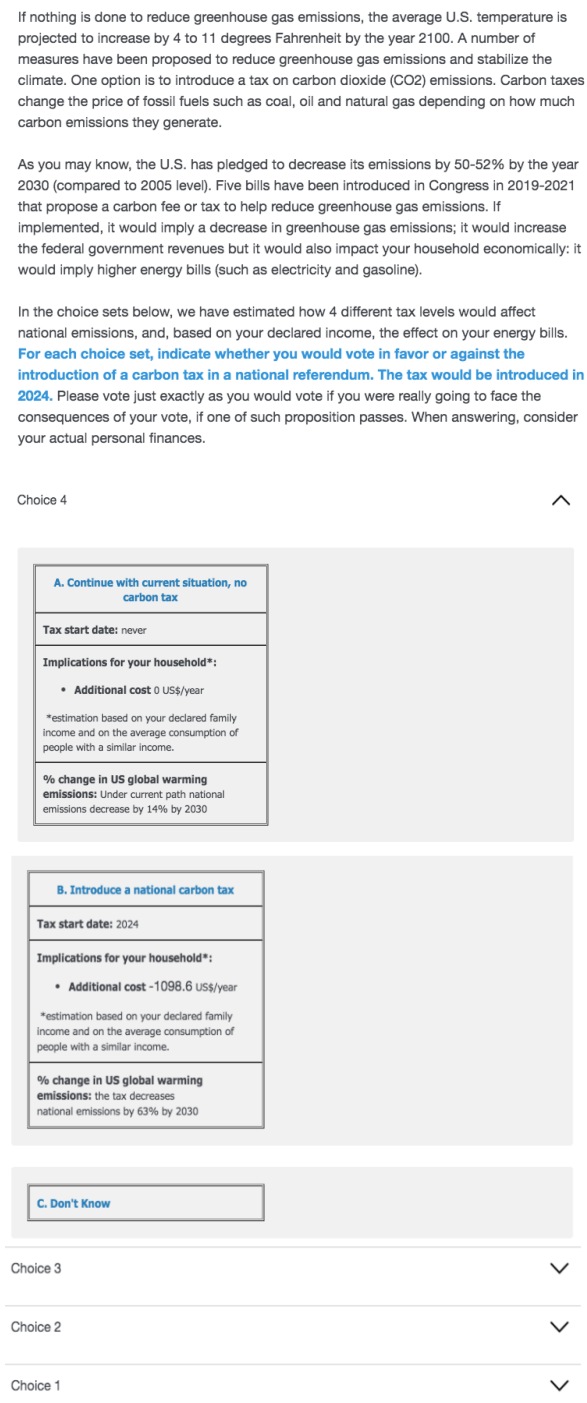
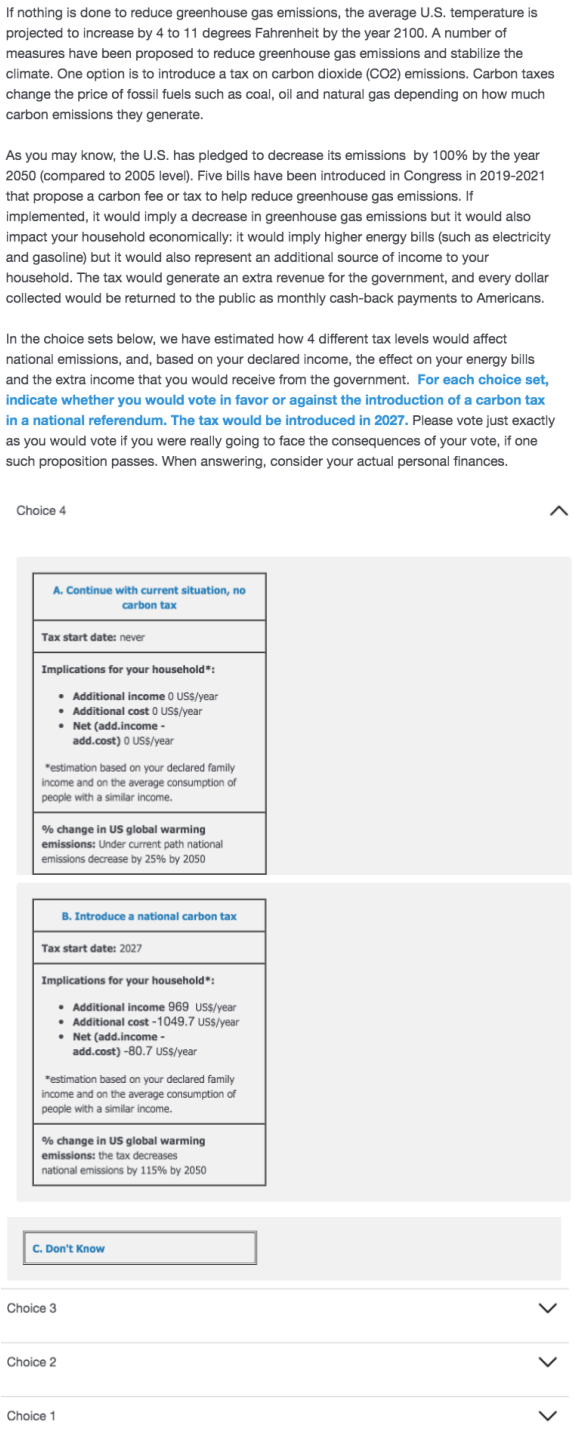


FIGURE 3.1.B Introduction and Choice task ex. Cashback, with start in 2027 and 2050 horizon



We then described the common benefits each policy alternative supposedly delivers in terms of *Percentage Change in the National CO_2 Emissions* with respect to 2005 levels. These objectives were estimated based on the tax level and were expressed under different *Temporal Horizons*—that is, the emission change that could be reached by either 2030 or by 2050. The absolute values by which US CO_2 emissions should

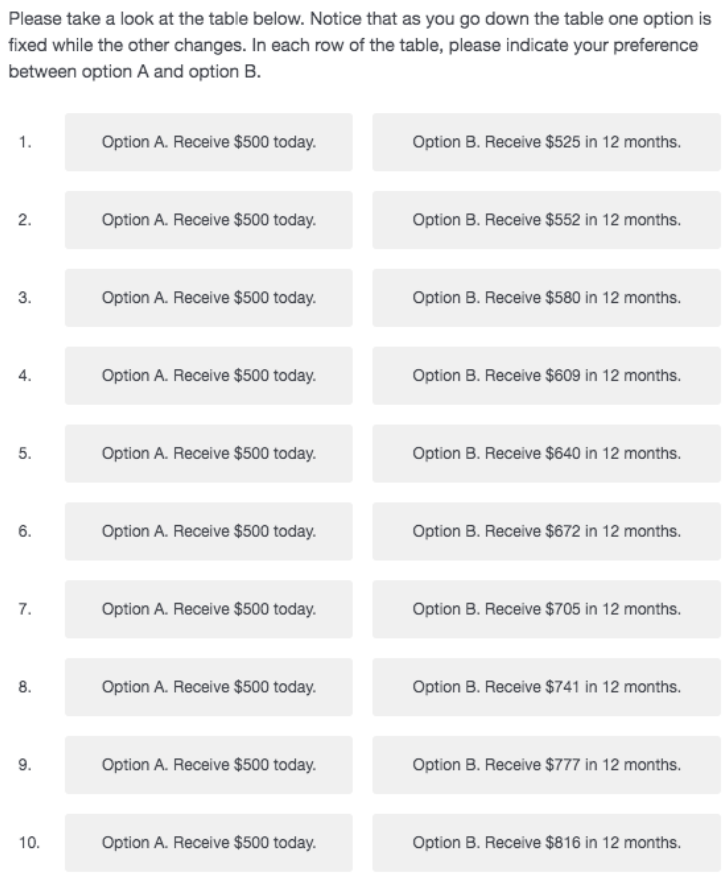
decrease compatibly with different global warming scenarios were taken from the Climate Action Tracker (2021), which also includes estimates of national emission paths under current scenarios[19]. Figure 3.1 includes a screenshot of how the survey looked like for an individual assigned to the Basecase condition (a) and Cashback condition (b). The introductory wording of our survey was partly borrowed from the NSEE (2016) and from Carattini et al. (2019) and adapted to meet our ends.

3.3.2 Post-experiment survey

3.3.2.1 Individual time preferences

We used a common approach in the literature to elicit individual time preferences which consisted of a multi-pricelist choice task as in Andersen et al. (2006) and Coller and Williams (1999). Respondents repeatedly chose between a smaller–sooner (option A) and a larger–later payment (option B), as shown in Figure 3.2 below. The more immediate payment was set to US$500 in a month, whereas the latter reward was US$500 + X, available in 1 year. X is a positive number that increases with each iteration. X is calculated using an annual rate of return between 5–50% on the principal, as in Andersen et al. (2006). Interest is compounded monthly based on major US bank's business practices. The point at which individuals switch from choosing the more immediate payoff to preferring the future income identifies the individual's discount rate.

FIGURE 3.2 Intertemporal choice task



[19] The Climate Action Tracker estimates national emission pathways and whether they align with the Paris Agreement long-term temperature objectives by using a carbon-cycle/climate model (MAGICC6). The methodology of the model is described in Meinshausen et al. (2009, 2011) and Rogelj et al. (2012).

3.3.2.2 Additional data

In addition, we recorded data on:

- Income
- Education level
- Political identity
- Area classification: Rural, town, metropolitan
- Environmental values
- Climate change beliefs
- Social expectations regarding other's willingness to pay for the environment
- Self-assessed level of selfishness/altruism on a 1–5 scale
- Trust in political institutions: 0–10 index based on expressed trust towards the US Congress, the US Federal Government, and politicians.

The following sociodemographic information on participants was already available from Prolific: age, sex, nationality, current country of residence/state of US residence, country of birth, employment status, and student status. We enriched our dataset by collecting information on the US states that had a carbon pricing scheme in place at the time of the survey.

3.3.3 Analysis

Outcome variables and analysis

To establish the determinants of the acceptability of the tax, we estimated regressions of the form:

$$Y_{(i,c)} = F(PolicyTemporalSetting_{(p)}, PolicyCost\&Revenues_{(i,p,t)}, PolicyRevenueUse_{(r)}, IndividualCharacteristics_{(i)}, StateLevelControls_{(s)}) \quad (1)$$

The response variable $Y_{(i,c)}$ records whether the individual *(i)* voted in favor of the carbon tax design contained in one of the four choice sets *(c)* to which he/she was exposed. It is modeled as a function of:

i) one of the six temporal settings of the policy design (*p*);
ii) the costs and the revenues that the policy eventually imposes on the household, calculated based on the individual (*i*)'s household income, the policy temporal setting *(p),* and the four tax baseline levels *(t)*;
iii) the policy's use of revenues *(r)* as either cashback payments or payments to the general federal budget;
iv) personal characteristics of individual *(i)*, including political and environmental beliefs, personal discount rate, and demographic data; and
v) state level controls, including whether the state in which individual *(i)* lives has already initiated a carbon pricing scheme.

Controls (iv) and (v) increase the precision of our estimates and correct for the possible sociodemographic imbalances observed between groups.

3.4 Results

We fielded our survey between July 29 and August 4, 2021 on Prolific Academic. Our sampling was restricted to US residents aged 18 or older. Remuneration for participation in the survey was an amount

proportional to the time spent on the survey paid at US minimum wage. Median completion time was five minutes, with most respondents completing the survey in four–seven minutes. A total of 1,092 respondents participated in our survey, and 1,013 (92.8%) completed it to the end. Of these, 13 (1.3%) were excluded from the analysis for failing attention checks, thus leaving us with 1,000 individuals who formed our final survey sample. They replied to four experimental choice sets, thus generating a total of 4,000 observations. While random assignment of participants across treatments should lead to homogenous groups, we calculated descriptive variables of the sample by group to ensure that the groups were balanced (Table 3.3).

The distribution of age, educational attainments, and individual discount rate were homogenous across groups as shown by the *p*-values of the ANOVA test of equal variances (for the continuous variables) and the *p*-value of the Kruskal-Wallis test (for the ordinal variables). We detected slight imbalances in the re-partition of individuals across gender, ethnicity, income, and political partisanship. These imbalances were accounted for in the econometric analysis through control variables. To show the comparability of our sample to the US national population, we included statistics in Table 3 on American households using the latest data from the US Census Bureau (2021), the OECD (2021), and Gallup Consulting (2021). Despite minor differences in average age (44.3 vs. 46.9), political partisanship (22% vs. 24% identifying as Republicans), and educational attainment (59% vs. 48% with at least a bachelor's degree[20]), our sample matches well the average US household.

[20] The percentage of Americans with minimum a bachelor degree comes from the OECD and it is possibly an underestimate since it excludes people below 25 years of age and since it refers to 2019, while the rate of Americans with a university degree keeps growing year on year and is likely to be higher for 2021.

TABLE 3.3 Main descriptive statistics of the sample by group

	TREATMENTS												p-value from F test	WHOLE SAMPLE	US POPULATION
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)			
Variables	**2021/2030 Cashback**	**2021/2030 Basecase**	**2024/2030 Cashback**	**2024/2030 Basecase**	**2027/2030 Cashback**	**2027/2030 Basecase**	**2021/2050 Cashback**	**2021/2050 Basecase**	**2024/2050 Cashback**	**2024/2050 Basecase**	**2027/2050 Cashback**	**2027/2050 Basecase**			
Mean age	46.0 (0.882)	43.6 (0.882)	43.8 (0.942)	45.3 (0.938)	46.3 (0.995)	43.3 (0.890)	42.1 (0.901)	43.3 (0.921)	45.2 (0.922)	43.9 (0.838)	45.3 (0.853)	43.2 (0.903)	0.459	44.3 (0.261)	46.9* (0.905)
Female (%)	49%	49%	65%	52%	51%	45%	50%	52%	49%	53%	48%	49%	0.004	51%	51%*
Ethnicity (White/non-Hispanic)	72%	66%	72%	75%	76%	73%	62%	74%	80%	70%	77%	72%	0.006	72%	72%*
Median Household Income	$66,338	$67,692	$68,338	$64,648	$64,994	$56,044	$65,939	$63,063	$55,874	$70,645	$66,494	$64,753	0.062	$65,330	$65,712*
Education (bachelor's and higher)	61%	60%	55%	53%	61%	64%	58%	69%	60%	52%	62%	55%	0.991	59%	48%**
Individual Discount Rate (scale 1-11)	5.44 (0.198)	5.58 (0.180)	5.62 (0.193)	5.62 (0.195)	5.27 (0.187)	6.21 (0.205)	5.57 (0.206)	4.97 (0.187)	5.59 (0.201)	4.71 (0.187)	5.78 (0.188)	5.76 (0.205)	0.137	5.51 (0.056)	NA
Identifies with the Republican party (%)	16%	34%	16%	25%	26%	22%	21%	29%	14%	18%	23%	23%	0.000	22%	24%***
N. participants	320	328	324	340	320	344	336	320	340	332	344	352	NA	1000	NA

Notes:

* National gender, age, ethnicity, and income data came from the U.S. Census Bureau (2021).

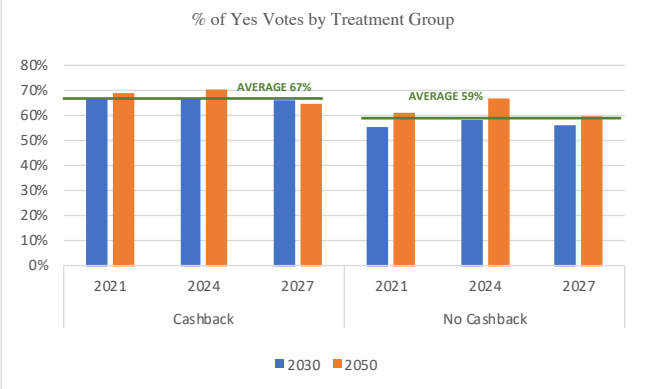
**Educational attainment data for Americans aged 25-64 came from the OECD (2021).

***The percentage of Americans considering themselves Republicans is the June 2021 figure from Gallup Consulting (2021).

3.4.1 The temporal distribution of carbon taxes' costs and rewards that increase their public acceptance

We start with a graphical representation of our key results. The variable of interest across all groups is the percentage of participants voting in favor of the introduction of the carbon tax. As shown in Figure 3.3, the proportion of yes votes ranges between 55% and 69%, depending on treatment. These percentages are in line with the latest available opinion polls that registered approval rates of 50% (five years earlier in 2016) or 67% (Puskin & Mills, 2017; Leiserowitz et al., 2020). The difference in approval rates between treatments is statistically significant (F: 3.71, Pr>F=0.000) and is thus a sign that the temporal setting of a tax in terms of its introduction and the horizon by which its environmental objectives are expressed have an influence on its political acceptance. Predictably, tax acceptance is higher when revenue use is channeled back to citizens in the form of cashback payments, reaching 67% on average. When revenues are simply conferred to the federal government budget, yes votes reach 59% on average.

FIGURE 3.3 Percentage of yes votes by treatment group



Source: based on own data. Note: "Don't Know" answers are counted as No.

There is clear variation, however, in the acceptance rates, depending on the start date of the policy and the temporal horizon by which emission reduction targets are expressed. The tax approval rates appear to be highest for the scenarios that introduce the tax in 2024 following a 3-year delay as compared to the immediate introduction and the 6-year delay scenario. In our design, delaying the introduction of the tax implies a higher tax rate and hence higher cost implications for the average household proportionate to the length of the delay. This was intentionally done to reflect the fact that delaying the start of a carbon tax would need to be compensated with higher starting fees to still reach the Paris Agreement global warming mitigation objectives. Presumably due to the effect of individual discounting of future outcomes[21], participants were more likely to commit to a carbon tax if delayed by 3 years, despite the slight cost increase it would bring about for their households. However, it appears that the cost increase in the 2027 scenario is big enough to more than offset the effect of individual discounting and any potential increase in yes votes that could have been brought about by a further delayed introduction. Expressing the emission reduction achieved by the tax by different temporal horizons had a detectable effect on acceptance rates: on average, the 2050 horizon achieved a higher consensus of 65% compared to 61% for scenarios in which 2030

[21] The fees and associated household costs were intentionally undiscounted for three reasons. First the acceptable objective rate of discounting to apply to future outcomes is highly controversial; second he concept of discounting is too complex to explain to laypeople and third, we wanted to let individuals to apply their own discount rate and, as we measure individual discount rates exogenously after the experiment, we are able to use our estimated individual discount rates to disentangle the effect of individual discounting, temporal setting and tax level.

emissions abatement objectives were mentioned. Constituents saw the tax more favorably when it was framed in a longer-term horizon with more ambitious environmental objectives.

Table 3.4 reports our regression estimations. Columns 1–8 show the effect of policy attributes on the likelihood that individuals would vote in favor of a national referendum on the introduction of a carbon tax. The first four covariates are dummy variables identifying the treatments. Their coefficients in column 1 are statistically significant at the 99% confidence level. They show that: individuals are more likely to approve carbon tax designs that a) include cashback payments; b) extend their environmental objectives to 2050 as opposed to 2030; and c) start with a 3–6 year delay once the price of the carbon tax is controlled. As expected and in line with the literature (Gevrek & Uyduranoglu, 2015; Carattini et al., 2017), approval decreases with tax rates and the associated additional cost that a tax imposes on households (column 3)[22]. Predictably, tax acceptance increases with each additional US$ of revenue from the cashback payments.

As shown in column 2, we repeated the same regression by excluding individuals that expressed some degree of uncertainty regarding their votes. The coefficients confirm the results from the previous regression both in terms of statistical significance and signs. In column 4, we addressed the slight gender, income, ethnicity, and political imbalances observed across treatment groups. The addition of these control variables left our previous results unchanged. In column 5, we included a dummy variable which captures whether or not living in a state that has already adopted carbon pricing in some form positively affects individual acceptance rates; the coefficient is statistically significant at the 99% confidence level and it has a positive sign. As shown in column 6, we additionally controlled for individual level fixed effects, which left our core results unchanged. Columns 7 and 8 show results when we included controls for the emission abatement objectives of each design. The coefficients are statistically significant and have a negative sign, while the coefficients for household costs lose significance. This is clearly due to multicollinearity between the cost of the tax and the amount of emissions it promises to abate[23].

[22] As mentioned in the method section, cashback payments and household costs are calculated based on the participant's declared income, and they are designed to be progressively smaller the richer the individual is. For this reasons, we substitute household cost and revenues from the tax with tax level due to their high correlation with income.

[23] As per our experimental design the percentage of emissions that a carbon tax design can achieve depends on the tax level and consequently, a tax that pursue more ambitious environmental objectives also translates into a higher cost of the tax for households.

TABLE 3.4 Regression output

Variables	(1) Logit	(2) Logit If vote certainty 4-7[c]	(3)	(4) Logit	(5) Logit	(6) Logit	(7) Logit	(8) Logit	(9) Logit	(10) Logit	(11) Logit	(12) Logit	(13) Margins of reg. 11	(14) Logit If vote certainty 4-7[c]	(15) Logit If vote certainty 6-7[c]
Policy characteristics															
Policy Start 2024 (dummy)	0.323*** (0.088)	0.270*** (0.096)		0.201** (0.094)	0.174* (0.099)	0.205** (0.095)	0.124 (0.084)	0.139* (0.084)				0.236** (0.105)	0.041** (0.018)	0.244** (0.118)	-0.253 (0.197)
Policy Start 2027 (dummy)	0.406*** (0.111)	0.346*** (0.120)		0.414*** (0.119)	0.444*** (0.126)	0.417*** (0.120)	0.033 (0.092)	-0.000 (0.092)				0.584*** (0.133)	0.099*** (0.021)	0.622*** (0.148)	0.219 (0.233)
Horizon 2030 (dummy)	-0.159*** (0.066)	-0.141** (0.071)	-0.164*** (0.065)	-0.145** (0.070)	-0.116[a] (0.074)	-0.128* (0.071)	-0.633*** (0.117)	-0.159*** (0.066)				-0.158** (0.079)	-0.027** (0.014)	-0.119 (0.088)	-0.288* (0.147)
Revenue as cashback (dummy)	0.331*** (0.066)	0.349*** (0.071)		0.259*** (0.070)	0.247*** (0.074)	0.249*** (0.071)	0.329*** (0.139)	0.402*** (0.137)				0.371*** (0.079)	0.065*** (0.014)	0.389*** (0.088)	0.376*** (0.149)
Hh Cost			-0.000*** (0.000)				-0.000 (0.000)	-0.000* (0.000)							
Hh Revenue			0.000*** (0.000)				7.29 e-06 (0.000)	-0.000 (0.000)							
Tax level	-0.008*** (0.001)	-0.008*** (0.001)		-0.010*** (0.001)	-0.011*** (0.001)	-0.010*** (0.001)						-0.011*** (0.001)		-0.012*** (0.002)	-0.008*** (0.003)
Emissions abated							-1.016*** (0.207)								
Emissions objective meets national commitment (dummy)								-0.303*** (0.074)							
Individual characteristics															
Intertemporal discount rate (1-11 scale)									-0.045*** (0.010)	-0.041*** (0.010)	-0.036*** (0.011)	-0.034*** (0.011)		-0.027** (0.013)	-0.081*** (0.021)
Republican Party (dummy)				-1.770*** (0.085)	-1.887*** (0.091)	-1.725*** (0.085)			-1.396*** (0.087)	-1.269*** (0.089)	-1.355*** (0.097)	-1.254*** (0.101)	-0.250*** (0.021)	-1.261*** (0.111)	-1.778*** (0.173)
Income				-2.15 e-06 (7.89 e-06)	-7.09 e-06 (8.49 e-06)	-1.26e-06 (8.09 e-06)			-2.48 e-06*** (8.25 e-06)	-2.56 e-06*** (8.30 e-06)	-3.48 e-06*** (9.23 e-06)	-3.43 e-06*** (9.235 e-06)		-5.84 e-06*** (1.05 e-06)	-1.04 e-05*** (1.83 e-06)
NoRespEnvironment (dummy)									-0.375** (0.162)	-0.225 (0.169)	-0.598*** (0.184)				
Selfishness (dummy)									-0.801*** (0.086)	-0.791*** (0.087)	-0.825*** (0.094)	-0.838*** (0.095)	-0.158*** (0.019)	-0.826*** (0.105)	-1.088*** (0.175)
No social norm (dummy)									-0.479*** (0.075)	-0.482*** (0.076)	-0.546*** (0.082)	-0.587*** (0.083)	-0.106*** (0.015)	-0.716*** (0.094)	-0.730*** (0.153)
Political trust (1–10 scale)									0.119*** (0.017)	0.098*** (0.017)	0.160*** (0.019)	0.139*** (0.020)		0.148*** (0.022)	0.322*** (0.035)
Climate change denial (dummy)										-1.852*** (0.258)		-1.897*** (0.284)	-0.360*** (0.0498)	-2.273*** (0.318)	-4.310*** (0.808)
Demographic controls															
Age											-0.022*** (0.002)	-0.021*** (0.002)		-0.024*** (0.003)	-0.039*** (0.005)
Female (dummy)				0.140** (0.071)	0.205** (0.075)	0.084 (0.071)					0.161** (0.083)	0.130 (0.085)	0.023 (0.015)	0.268*** (0.096)	0.759*** (0.164)
Unemployed (dummy)											-0.076 (0.150)	0.036 (0.156)	0006 (0.027)	-0.063 (0.170)	0.468 (0.331)
Education: minimum bachelor's degree (dummy)											-0.027 (0.086)	-0.003 (0.088)	0.001 (0.015)	0.079 (0.098)	0.068 (0.166)
Rural (dummy)											-0.251* (0.141)	-0.305** (0.142)	-0.055** (0.026)	-0.286* (0.157)	-1.206*** (0.242)
Ethnicity and nationality controls	N	N	N	Y	Y	Y	N	N	N	N	Y	Y		Y	Y
State level controls	N														
State level carbon tax in place					0.233*** (0.084)										
Current state of residence controls	N	N	N	N	N	N	N	N	N	N	Y	Y		Y	Y
Individual fixed effects	N	N	N	N	N	Y	N	N	N	N	N	N		N	N
Observations	4000	3568	4000	4000	3660 [b]	4000	4000	4000	3880	3880	3844	3844		3420	1968
Pseudo R-squared	0.014	0.014	0.005	0.107	0.121	0.116	0.014	0.013	0.132	0.146	0.177	0.200		0.235	0.421
P-value F test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000

Notes. * Significant at <.10, ** significant at <.05, *** significant at <.01. Standard errors in parentheses. [a] P-value F test nearly statistically significant at 0.11. [b] Fewer observations due to missing data on US state of residence. [c] Individuals rated the certainty of their votes on a scale from 1–7, from very uncertain to very certain.

Columns 9–11 focus on the individual level characteristics affecting choice. People who more greatly discount future outcomes and who identify with the Republican Party are less likely to be in favor of the tax (the coefficients are statistically significant with negative signs). A higher income negatively correlates with tax acceptance, clearly reflecting the fact that individuals with a higher income incur higher cost increases in absolute terms and receive smaller cashback payments. We find that individual beliefs concerning the environment and society in general affect choice. Individuals who decline any personal responsibility to care for the environment, who think that others would not pay a price to protect the environment, and who are not persuaded that climate change is currently happening are less likely to vote for the tax. As a measure of pro-social orientation, we asked participants whether they thought that one should focus on his/her own life and not bother too much with helping others. People who agreed with this statement were less likely to approve of the tax. In line with previous finings in the literature (Umit & Schaffer, 2020), we find that our index measuring trust in institutions on a 0–10 scale positively correlates with tax approval. The more an individual trusts the federal government, the US Congress, and politicians, the more likely she/he is to avail of carbon pricing at the federal level. By looking at demographic characteristics, we find that carbon tax support decreases with age and it is smaller amongst males and people living in rural areas. It is possible that people living in rural areas anticipate that the cost imposed on them by the tax may actually be higher than the ad-hoc figures included on the choice cards, owing to longer commuting distances and fossil fuel consumption connected to rural living. This is in line with Umit & Schaffer (2020), who found that individuals who are more dependent on energy are more averse to carbon taxes. We did not find a statistically significant effect of unemployment or of education[24].

When we conjoin individual characteristics and policy attributes in the same regression (columns 12–16), our aforementioned findings are confirmed in terms of statistical significance and signs. The explanatory power of our model so defined increases with the degree of certainty that participants attached to their choices, ranging from 20% when the whole sample was included to 42% when only people who were highly certain of their choices were included. Column 13 reports marginal effects computed for regression 12. We find that when the effect of the cost of the tax on households is controlled, asking individuals to pre-commit to a carbon tax that starts 3 or 6 years in the future increases acceptance by 4% and 10%, respectively, compared to introducing it immediately. The promise of cashback payments increases acceptance by nearly 7%, while expressing environmental objectives for 2050 (which involves a longer-term commitment to more ambitious objectives) would increase support by almost 3%. Amongst the individual level characteristics that affect choices the most, we find that denial of the occurrence of climate change reduces the probability to approve it by 36%. People who identify with the Republican Party and more self-focused individuals are respectively 25% and 16% less likely to vote in its favor.

We ran split regressions of different population subsets identified by policy attributes or individual characteristics to examine whether the determinants of choice are specific to a given group. We thus reran the regression in (12), splitting the sample into different groups. We start by noting that R^2 rose from 20% up to 30% with split regressions (19). This indicates that there are significant changes in the variables affecting choice in each group. We first ran the regressions split by whether the choice cards solely mentioned the cost of the tax to American families or whether they also included the sum that they would receive as monthly cashback payments (Table 3.5, columns 17–18). In the cashback condition (18), we find that the temporal framing of the policy loses relevance: of the three coefficients identifying the temporal frame of choice, only one is statistically significant. For individuals in the Basecase condition, all three coefficients are statistically significant; in this group, individuals care to postpone the start of the policy as long as possible and are more likely to be in favor of the tax when it is presented in terms of its more ambitious and temporally distant 2050 policy goals. We also find that in the cashback condition, individual time discounting does not affect tax acceptance. This is possibly a

[24] Beyond the dummy variable for people with at least a bachelor degree which is included in the regressions we also tested as alternative measure an educational attainment scale from 1–10 and a dummy variable for people who currently are students. They also did not give any statistically significant result.

sign that when the carbon tax is attached to a private economic compensation which is delivered at the same time, individuals do not perceive the choice situation as one involving an intertemporal tradeoff.

3.4.2 The effect of intertemporal discounting on tax acceptance

As shown in columns 19–20, we looked at whether the determinants of choice changed depending on individual intertemporal preferences. We find that more patient individuals (i.e., that discount future outcomes less) are more likely to approve of the tax if presented with more ambitious but distant 2050 climate goals. For more present-focused participants, the 2030 coefficient is not statistically significant.

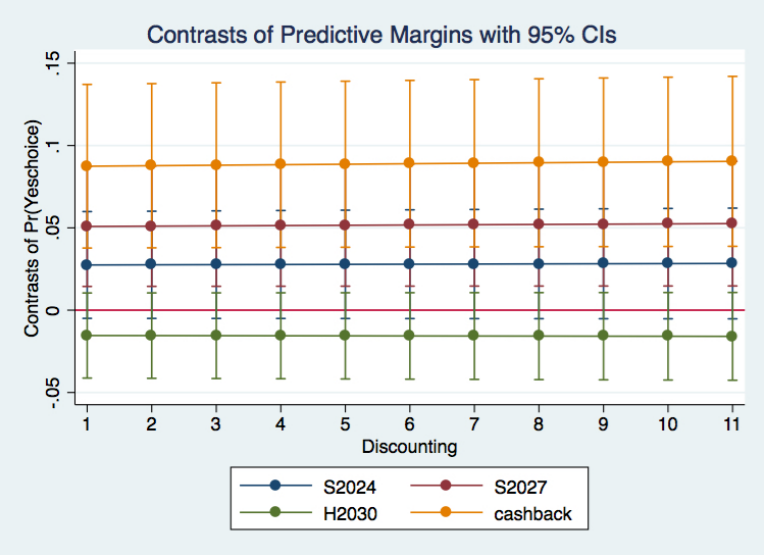
TABLE 3.5 Split regression output

Variables	**(17)** **No cashback**	**(18)** **Cashback**	**(19)** **LowDisc scale <3**	**(20)** **HighDisc scale >8**
Policy characteristics				
Policy Start 2024 (dummy)	0.539*** (0.157)	0.004 (0.160)	0.272 (0.260)	0.027 (0.208)
Policy Start 2027 (dummy)	0.934*** (0.196)	0.426** (0.202)	1.126*** (0.343)	0.433* (0.151)
Horizon 2030 (dummy)	-0.197* (0.118)	-0.161 (0.120)	-0.638*** (0.216)	-0.164 (0.151)
Revenue as cashback (dummy)			1.036*** (0.208)	0.276* (0.158)
Tax level	-0.016*** (0.002)	-0.007*** (0.002)	-0.016*** (0.004)	-0.005* (0.003)
Individual characteristics				
Intertemporal discount rate (1-11 scale)	-0.036** (0.017)	-0.023 (0.018)		
Republican Party (dummy)	-1.278*** (0.145)	-1.321*** (0.163)	-1.670*** (0.292)	-1.214*** (0.194)
Income	-4.71 e-06*** (1.39 e-06)	-3.74 e-06*** (1.39 e-06)	-8.31 e-06*** (2.52 e-06)	-3.23 e-06*** (1.92 e-06)
Selfishness (dummy)	-0.731*** (0.142)	-1.047*** (0.145)	-1.093*** (0.266)	-0.603*** (0.169)
No social norm (dummy)	-0.590*** (0.123)	-0.535*** (0.129)	-0.492*** (0.204)	-0.340* (0.198)
Political trust (1–10 scale)	0.165*** (0.029)	0.113*** (0.031)	0.266*** (0.049)	0.060 (0.039)
Climate change denial (dummy)	-2.595*** (0.468)	-1.862*** (0.396)	-1.564** (0.703)	-2.179*** (0.408)
Demographic controls	Y	Y	Y	Y
Ethnicity and nationality controls	Y	Y	Y	Y
Current state of residence controls	Y	Y	N	N
Individual fixed effects	N	N	Y	Y
Observations	1936	1888	896	1064
Pseudo R-squared	0.240	0.222	0.300	0.177
P-value F test	0.000	0.000	0.000	0.000

Notes. * Significant at <.10, ** significant at <.05, *** significant at <.01. Standard errors in parentheses.

To check whether the effect of individual temporal preferences depended on condition, we calculated the marginal effects of policy attributes (namely, policy start in 2024 or 2027; 2030 as emission horizon; and cashback) for each additional unit increase in the temporal discount scale (Figure 3.4, calculated based on the equation in column 12, Table 4). The effect of being included in the 2024, 2027 and cashback group positively contributed to the likelihood of voting in favor of the tax (compared to the Basecase 2021 group). The effect of these three policy attributes is statistically significant and it is stronger on individuals with higher discount rates. This finding matches the intuition that postponing the tax is more appealing to individuals who are present-focused and who more greatly discount future costs.

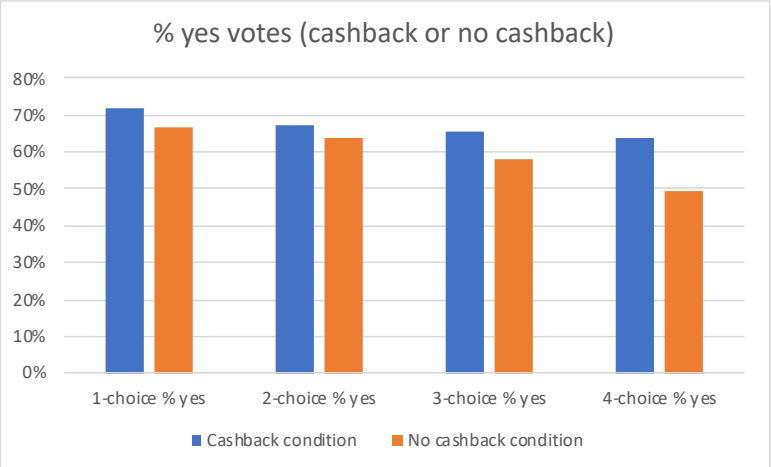
FIGURE 3.4 Marginal effects of policy attributes on temporal preferences



3.4.3 The political feasibility of a Paris Agreement's objective-compatible tax

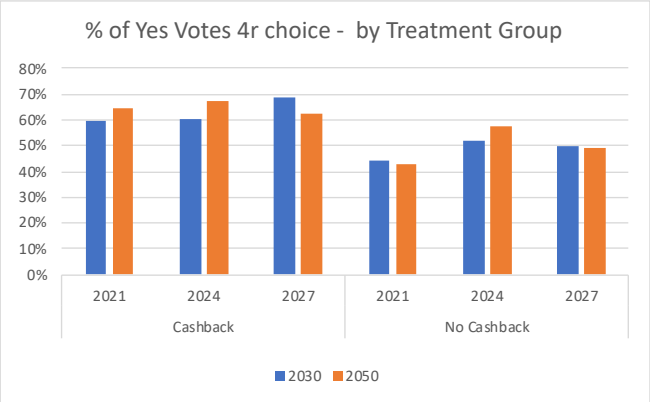
Figure 3.5 depicts the percentage of yes votes by taxation level. Each individual voted the same carbon tax design four times (as defined by start of the policy, temporal emission horizon, and revenue use), with only variations in the taxation level (and the associated costs, revenues, and emission cuts). The four baseline tax levels voted upon were 15, 40, 60, and 80 US$. These rates were adjusted proportionally to the delay with which the policy was introduced for individuals in the 2024 and 2027 delay conditions. As the Figure shows, acceptance is highest in the first choice set when the tax rate and the cost implications for households are lowest and it gradually decreases as the costs increase. Qualitative analysis of the sentences written by participants to explain their choices in the pilot phase confirms that for some there is a switch point at which the cost of the tax simply becomes too high to the individual either in relation to his/her income, policy environmental objectives, or both. It should be noted that in the no cashback condition, individuals are predictably more sensitive to tax increases, and the percentage of yes votes decreases more markedly in this condition, whereas it appears to be more stable for participants that receive money back. This shows that in a carbon tax policy with a cashback program, individuals would potentially accept a level of taxation that would be politically unfeasible in the absence of this revenue redistribution.

FIGURE 3.5 Percentage of yes votes by taxation level, cashback versus no-cashback



In particular, the fourth choice set which corresponds to the tax level that has the highest probability of compatibility with Paris global warming objectives falls short of the majority approval in the no cashback condition with 49% of yes votes, while it appears to be politically feasible in the cashback condition. Figure 3.6 shows the temporal treatment that maximizes the percentage of yes votes by focusing only on the fourth choice. The figure shows that if we focus on taxation levels consistent with Paris global temperature objectives but we do not want to earmark revenues, then the ideal policy horizon that maximizes acceptability is the 2024/2050 horizon.

FIGURE 3.6 Percentage of yes votes by treatment group, third choice only



3.4.4 Political relevance analysis

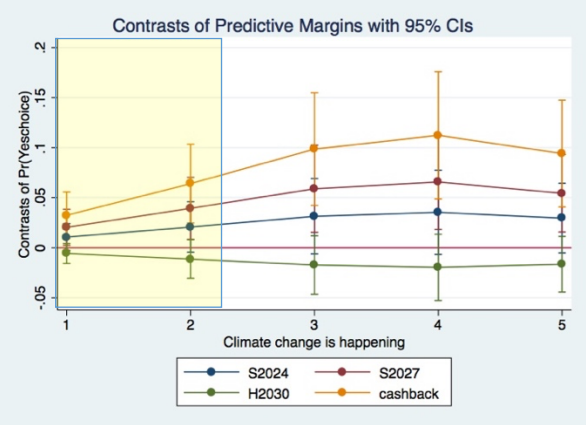
There are pools of participants that are either against or in favor of the carbon tax at all tax levels. Even though they constitute a minority, they may still constitute a politically relevant group. It is thus of interest to understand whether or not there is a temporal framing of a carbon tax that can persuade them. As noted earlier, among the analyzed individual characteristics, the primary ones that negatively affect tax acceptance are: a) the belief that climate change is not currently happening; b) political identification with the Republican Party; c) distrust in institutions; and d) refusal to ascribe to personal responsibility for protecting the environment.

Figure 3.7 shows the marginal effects of policy attributes (policy start in 2024 or 2027, 2030 as emission horizon, and cashback) for each additional unit increase in the climate belief scale, political scale, trust index, and environmental responsibility scale (calculated based on the equation in column 12, Table 3.4).

The yellow areas in the graphs correspond to individuals that match the four characteristics just described. Across the four groups, inclusion in the cashback group and in the treatment group in which the tax starts in 2027, followed by a tax design that starts in 2024, have the biggest impact on the probability of approving the tax, and these effects are statistically significant. These effects are positive for any value of the four scales under consideration; they are strongest for individuals identifying as Republicans, people with low trust in public institutions, and people who deny any personal environmental responsibility. On the contrary, these treatments are not as effective on individuals who do not recognize that climate change is occurring. These graphs indicate that one of these features or a combination thereof may help to persuade a potentially politically relevant section of the American population to approve a carbon tax.

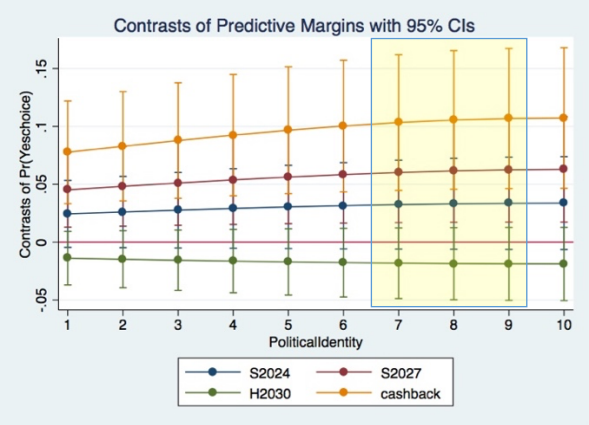
FIGURE 3.7 Marginal effects of policy attributes on nay-sayers

6.a Climate change belief scale*



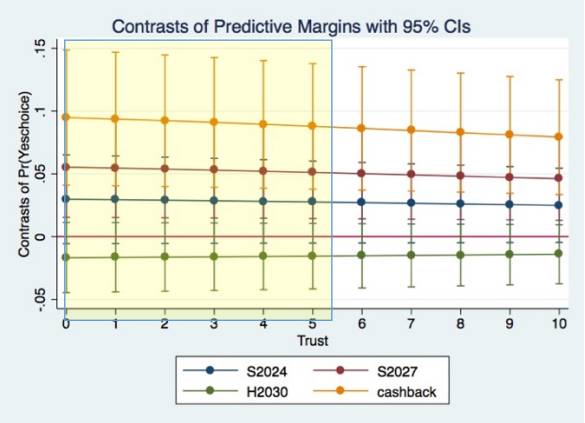
*Horizontal axis values 1–2 correspond to "climate change is not happening."

6.b Political identification scale**



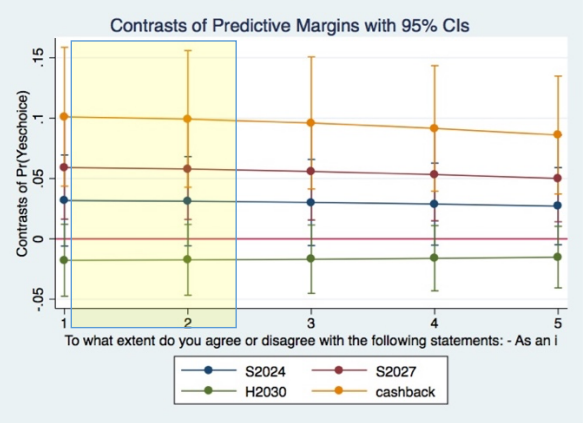
**Horizontal axis values 7–9 correspond to "Identifies as Republican".

6.c Trust in public institutions index***



***Horizontal axis values 1–4 correspond to "Mostly distrust public institutions."

6.d Personal responsibility scale****



****Horizontal axis values 1–2 correspond to "Denies personal environmental responsibility".

3.5 Conclusions

The literature on intertemporal choice and cooperation tells us that cooperative outcomes are less likely in a scenario in which costs are immediately imposed for rewards that are shared and will occur further in the future. This is the standard temporal context of a global tax which imposes from its beginning costs on a constituency for environmental benefits that will only occur in the distant future.

The intertemporal dimension of carbon taxes and its effect on public acceptability has not been previously studied. This is the first paper to explore whether the temporal contextualization of carbon taxes can be designed in a way that increases their popularity. In particular, we analyzed whether asking people to pre-commit to a carbon tax that starts a few years from now increases its public support and whether individuals prefer that its target emission cuts are expressed by a more proximal or distant date. This is also the first study to analyze whether individual temporal preferences affect the acceptability of carbon taxes.

We find that it is possible to design carbon taxes that optimize the temporality of tax costs and benefits. Ceteris paribus, Americans are more likely to commit to a carbon tax if the economic costs it imposes on households can be slightly shifted to the future (by postponing the start of the policy by a few years). This is possibly due to individual discounting as individuals typically discount future costs, and the amount of discounting applied to future outcomes increases with the distance considered. Americans also are more approving of a carbon design that includes private benefits—such as the redistribution of

dividends to the population—that are immediately available. Furthermore, people are also more likely to favor a carbon tax if justified by more ambitious albeit more temporally distant environmental objectives; for example, climate neutrality by 2050 is a more evocative goal than merely halving carbon emissions by 2030.

However, delaying the introduction of a carbon tax has clear biophysical consequences as the carbon budget that remains in order to stay within the Paris global warming objectives narrows with each year of delay. A delayed introduction would, therefore, require increasing the ambition of the tax by either adjusting its starting level or by scheduling steeper year-on-year increases. In this paper, we tested the former hypothesis, and we adjusted starting tax levels in proportion to the delay. A precise estimate of this adjustment is even more complex than estimating the taxation level required to meet the Paris objectives if the tax were to start immediately because it requires additional predictions and assumptions regarding the evolution of global emissions. Attempting an exact estimation is beyond the scope of our paper, but we propose an adjusted tax level which falls within the range of plausibility and which is intentionally an underestimate. We show that when individuals are confronted with the short-term opportunity cost that delaying the tax would potentially imply, they are not necessarily in favor of indefinitely postponing it. When the price of carbon is adjusted to take the delay into account, we see that individuals start to trade off tax postponement against the containment of costs. The exact switch point would ultimately depend upon the adjusted tax rate, individual discounting, and how the cost on households is derived, among other things.

As our descriptive findings in Figure 2 show, our conservative estimate of a tax increase which is proposed to meet the Paris objectives with a six-year delay is high enough to decrease tax approval rates as compared to 2021 and 2024. The political message is clear: while precommitment to costs that are slightly delayed may increase immediate political acceptance of a tax and increase the likelihood that a national referendum would pass, that increased support would be merely temporary and artificial unless the short-term opportunity costs of waiting were disclosed. The increased economic costs that a delay would entail as well as the increased environmental risk in the long-term should be clearly stated in any carbon tax proposal or postponement thereof that is passed on by the population.

Procrastinating on the approval of urgently needed carbon taxes for fear of voter opposition may not payoff in the long term, as the public opposition that politicians try to avoid today will likely increase proportionally to the length of the delay and the associated increase in mitigation costs that the policy would need to include. In addition, there are clear unknowns about tipping points and feedback mechanisms that imply a greater risk of catastrophic global warming events if climate mitigation policies are postponed and the concentration of CO_2 in the atmosphere becomes higher (Furman et al. 2014).

To maximize acceptability, the ideal carbon tax formulation should thus contain a dividend redistribution component, at least at its introduction, as this also appeals to groups of constituents that would typically oppose the tax, and it appears to halt the negative effect of individual discounting on the acceptability of the tax. Carbon tax policies should clearly describe their environmental objectives using the more ambitious long-term 2050 goals as a temporal horizon. When it comes to the ideal start time for the policy, there is likely to be a short-term tradeoff, in which postponing the policy by a few years may increase its acceptability but worsen its effectiveness and our overall likelihood of averting climate catastrophe. This finding applies to both the Baseline and the Cashback scenarios, although the effect of the temporal context appears to be stronger in the Baseline scenarios. In the longer-term, such a tradeoff is likely to resolve itself, as the increased cost of mitigation for longer delays is enough to erode any additional support which might come from the appeal of shifting costs to the future. The higher the opportunity cost of waiting, the less likely is a delayed introduction to win any additional support. Politicians could leverage this and include the additional costs that an increased risk of waiting could pose for the climate in their carbon tax proposition and communications. Future research could expand this work by looking at the effect of the timing of the cashback payments versus the timing of the increased costs that households would face every day.

3.6 References

Andersen, S., Harrison, G.W., Lau, M.I. et al. Elicitation using multiple price list formats. Exp Econ 9, 383–405 (2006). https://doi.org/10.1007/s10683-006-7055-6

Arora, P., Peterson, N. D., Krantz, D. H., Hardisty, D. J., & Reddy, K. S. (2012). To cooperate or not to cooperate: Using new methodologies and frameworks to understand how affiliation influences cooperation in the present and future. *Journal of Economic Psychology*, *33*(4), 842–853. https://doi.org/10.1016/j.joep.2012.02.006

Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R., Schuman, H. (1993). Report of the NOAA panel on Contingent Valuation.

Bachus, K., Van Ootegem, L., & Verhofstadt, E. (2019) 'No taxation without hypothecation': towards an improved understanding of the acceptability of an environmental tax reform, Journal of Environmental Policy & Planning, 21:4, 321-332

Bateman, I. J., Cole, M., Cooper, P., Georgiou, S., Hadley, D., Poe, G.L. (2004). On visible choice sets and scope sensitivity, Journal of Environmental Economics and Management, 47 (1), 71-93.

Baranzini, A., van den Bergh, J. C. J. M., Carattini, S., Howarth, R. B., Padilla, E., & Roca, J. (2017). Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations. *Wiley Interdisciplinary Reviews: Climate Change*. https://doi.org/10.1002/wcc.462

Bernatzi, S., Thaler, R.H. (2013). Behavioral Economics and the Retirement Savings Crisis, Science, 339, 6124, 1152-1153, doi: https//doi.org/10.1126/science.1231320

Bishop, R.C., Boyle, K.J. (2019) Reliability and Validity in Nonmarket Valuation. Environ Resource Econ 72, 559–582.

Brouwer, R., Dekker, T., Rolfe, J., Windle, J. Choice Certainty and Consistency in Repeated Choice Experiments. Environ Resource Econ 46, 93–109 (2010).

Carattini S, Baranzini A, Thalmann P, Varone P, Vöhringer F (2017) Green taxes in a post-Paris world: Are millions of nays inevitable? Environmental and Resource Economics: 1–32

Carattini, S., Kallbekken, S., Orlov, A. (2019) How to win public support for a global carbon tax. Nature 565, 289-291. doi: https://doi.org/10.1038/d41586-019-00124-x

Carattini, S., Levin, S., Tavoni, S. Cooperation in the Climate Commons, Review of Environmental Economics and Policy, Volume 13, Issue 2, Summer 2019, Pages 227–247, https://doi.org/10.1093/reep/rez009

Carson, R.T., Groves, T. Incentive and informational properties of preference questions. Environ Resource Econ 37, 181–210 (2007).

Center for Climate and Energy Solutions. (2021, May). U.S. State Carbon Pricing Policies. https://www.c2es.org/document/us-state-carbon-pricing-policies/

Climate Action Tracker (2021, April). USA Country summary. https://climateactiontracker.org/countries/usa/

Coller, M., Williams, M.B. Eliciting Individual Discount Rates. Experimental Economics 2, 107–127 (1999). https://doi.org/10.1023/A:1009986005690

Douenne, T. & Fabre, A. (2020). French attitudes on climate change, carbon taxation and other climate policies. Ecological Economics, 169. https://doi.org/10.1016/j.ecolecon.2019.106496

Douenne, T. & Fabre, (forthcoming). A. Yellow Vests, Pessimistic Beliefs, and Carbon Tax Aversion. American Economic Journal: Economic Policy. https://doi.org/10.1016/j.ecolecon.2019.106496

Drews, S., & van den Bergh, J. C. J. M. (2016). What explains public support for climate policies? A review of empirical and experimental studies. *Climate Policy*, *16*(7), 855–876. https://doi.org/10.1080/14693062.2015.1058240

Fehr, E., & Leibbrandt, A. (2011). A field study on cooperativeness and impatience in the Tragedy of the Commons. *Journal of Public Economics*, *95*(9–10), 1144–1155. https://doi.org/10.1016/j.jpubeco.2011.05.013

Furman, J, R Shadbegian and J Stock (2015), "The cost of delaying action to stem climate change: A meta-analysis", VoxEU.org, 25 February.

Gallup Consulting (2021). Party Affiliation. Retrieved August 9, 2021, from https://news.gallup.com/poll/15370/party-affiliation.aspx

Gevrek ZE, Uyduranoglu A (2015) Public preferences for carbon tax attributes. Ecological Economics, 118: 186–197. Available at: http://dx.doi.org/10.1016/j.ecolecon.2015.07.020

Gibbard, A. (1973). Manipulation of Voting Schemes: A General Result. Econometrica, 41(4), 587-601. doi:10.2307/1914083

Gollier, C. (2020). Climate economics form theory to policy. EAERE Magazine. n.8 Winter 2020, p. 6-8

Hendrickx, L., van der Kooij, R., & Poortinga, W. (2001). Temporal Factors in Resource Dilemmas. *Acta* Psychologica : European Journal of Psychonomics, 108(2), 137–154.

Heuermann, K. C. (Universitat zu K. (2015). Phd Dissertation: Topics in behavioral economics: cooperation in social dilemmas and intertemporal decision-making.

High-Level Commission on Carbon Prices. 2017. Report of the High-Level Commission on Carbon Prices. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO

Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. Journal of Experimental Psychology: General, 128, 78–87.

Jacquet, J., Hagel, K., Hauert, C., Marotzke, J., Röhl, T., & Milinski, M. (2013). Intra- and intergenerational discounting in the climate game. Nature Climate Change, 3(12), 1025–1028. https://doi.org/10.1038/nclimate2024

Johannesson, M., Blomquist, G.C., Blumenschein, K. et al. Calibrating Hypothetical Willingness to Pay Responses. Journal of Risk and Uncertainty 18, 21–32 (1999).

Leiserowitz, A., Maibach,E., Rosenthal, S., Kotcher, J., Carman, J., Wang, X., Goldberg, M., Lacroix, K., & Marlon, J. (2021). Politics & Global Warming. Yale Program on Climate Change and Communication report. https://climatecommunication.yale.edu/publications/politics-global-warming-december-2020/5/

Libecap G.D. (2008) State Regulation of Open-Access, Common-Pool Resources. In: Ménard C., Shirley M.M. (eds) Handbook of New Institutional Economics. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-69305-5_22

Louviere, J., Hensher, D., Swait, J., & Adamowicz, W. (2000). Stated Choice Methods: Analysis and Applications. Cambridge: Cambridge University Press.

McClearly, W. (1991) The World Bank Research Observer, Volume 6, Issue 1, Pages 81–104, https://doi.org/10.1093/wbro/6.1.81

McKibbin, W.J., Morris, A.C. and Wilcoxen, P.J. (2004) The Economic consequences of delay in U.S. climate policy, The Brookings Institute, Washington D.C. https://www.brookings.edu/wp-content/uploads/2016/06/03_economic_consequences_delay_us_climate_policy.pdf

Meinshausen M, Meinshausen N, Hare W, Raper S C B, Frieler K, Knutti R, Frame D J and Allen M R (2009) Greenhouse-gas emission targets for limiting global warming to 2 °C. Nature 458 1158–62

Meinshausen, M., S. C. B. Raper and T. M. L. Wigley (2011) "Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6: Part I – Model Description and Calibration", Atmospheric Chemistry and Physics 11 1417-1456

Puskin, D., Mills, S.B., (2017) “Moving the needle of Americans support for a carbon tax”, National Survey on Energy and Environment, Issues in Energy and Environmental Policy

National Surveys on Energy and Environment (2016), Data Tables 2016, University of Michigan. https://closup.umich.edu/research-projects/national-surveys-energy-and-environment/data-tables

OECD (2021). Adult education level. Retrieved August 9, 2021, from https://data.oecd.org/eduatt/adult-education-level.htm#indicator-chart

Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge: Cambridge University Press.

Palan, S., Schitter, C., (2018). Prolific.ac—A subject pool for online experiments. Journal of Behavioral and Experimental Finance, 17, 22-27. https://doi.org/10.1016/j.jbef.2017.12.004.

Peer, E., Brandimarte, L., Samat, S., Acquisti, A. (2017) Beyond the Turk: Alternative platforms for crowdsourcing behavioral research. Journal of Experimental Social Psychology. 70, 153-163. https://doi.org/10.1016/j.jesp.2017.01.006.

Rogelj, J., Meinshausen, M. & Knutti, R. (2012) Global warming under old and new scenarios using IPCC climate sensitivity range estimates. Nature Clim Change 2, 248–253. https://doi.org/10.1038/nclimate1385

Satterthwaite, M. A. (1975) Strategy-proofness and Arrow's conditions: Existence and correspondence theorems for voting procedures and social welfare functions, *Journal of Economic Theory*, 10 (2), 187-217.

Savin, I., Drews, S., Maestre-Andrés, S. et al. Public views on carbon taxation and its fairness: a computational-linguistics analysis. Climatic Change 162, 2107–2138 (2020). https://doi.org/10.1007/s10584-020-02842-y

Thaler, R.H. & Bernatzi, S. (2004). Save More Tomorrow™: Using Behavioral Economics to Increase Employee Saving, Journal of Political Economy, 112, S1, https://doi.org/10.1086/380085

The White House (2021, April 22). FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies. https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/

Tiezzi, S., & Xiao, E. (2016). Time delay, complexity and support for taxation. *Journal of Environmental Economics and Management*, *77*, 117–141. https://doi.org/10.1016/j.jeem.2016.03.002

Umit, R., & Schaffer, L. M. (2020). Attitudes towards carbon taxes across Europe: The role of perceived uncertainty and self-interest. *Energy Policy*, *140*. https://doi.org/10.1016/j.enpol.2020.111385

United Nations Environment Programme (2020). Emissions Gap Report 2020. Nairobi.

US Census Bureau (2021). United States Data 2019. Retrieved August 9, 2021, from https://data.census.gov/cedsci/profile?q=United%20States&g=0100000US, consulted on 09/08/2021

Weng, W., Morrison, M. D., Boyle, K. J., Boxall, P. C., Rose, J. (2021). Effects of the number of alternatives in public good discrete choice experiments. *Ecological Economics*, 182.